

SAA09FT01-006  
JUNE 1989

SYSTEM ASSURANCE ANALYSIS  
OF THE  
LINK-BELT 40-TON MOBILE CRANE HSP-8040  
AT THE  
KENNEDY SPACE CENTER

Baseline Number: 330.00

PMN: H72-1394

WUC: 99GKRLA000

SS: 99

SYSTEM: CRITICAL

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National Aeronautics and  
Space Administration

**John F. Kennedy Space Center**

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APPLICATION		PART NO.	MF	REVISIONS			
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UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS DECIMALS ANGLES	ORIGINAL DATE OF DRAWING	06-89	SYSTEM ASSURANCE ANALYSIS OF THE LINK-BELT 40-TON MOBILE CRANE HSP-8040 AT THE KENNEDY SPACE CENTER OMD BASELINE NO. 330.00	JOHN F. KENNEDY SPACE CENTER, NASA	
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MATERIAL	TRACER	CHECKER			
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## 1.0 SUMMARY OF FINDINGS

### 1.1 SYSTEM CRITICALITY

The Link-Belt 40-Ton Mobile Crane HSP-8040 System is assessed as critical because dropping the load could cause loss of life, vehicle and/or damage of a vehicle system. See section 2.4 for additional information.

### 1.2 MECHANICAL CRITICAL ITEMS

There were three Category 1 or 2 mechanical Critical Items identified in this analysis, which are summarized below. Additional information can be found in sections 2.5 and 3.0.

<u>Mechanical Critical Items</u>			
<u>Ref Des/ Find No.</u>	<u>Nomenclature</u>	<u>Critical Failure Mode</u>	<u>Failure Category</u>
Model 10/ Kit 420	Reduction Unit Assembly	Disengages	1
37805	Winch Brake Assembly	Brake slips or fails to engage	1
46F0085	Swing Speed Reducer Assembly	Disengages	2

### 1.3 ELECTRICAL CRITICAL ITEMS

There were no electrical critical items identified in this analysis.

### 1.4 CRITICAL CONTROL/MONITOR FUNCTIONS

There are no Launch Commit Criteria requirements for this system; therefore, no Launch Commit Criteria Review is required.

There are no LPS control/monitor functions associated with the critical functions identified in section 2.4 for this system.

There is no prerequisite or reactive control logic associated with the critical functions identified in section 2.4 for this system/equipment; therefore, no Software Application Set Review is required.

There are no Ground Launch Sequencer sequences required for the critical functions identified in section 2.4 for this system/equipment; therefore, no Ground Launch Sequencer Review is required.

There are no Launch Commit Criteria requirements for the critical functions identified in section 2.4 for this system/equipment; therefore, no Launch Commit Criteria Review is required.

### 1.5 HAZARDS IDENTIFIED

There were no hazards identified in this system.

### 1.6 CRITICAL FLEXHOSES

There were no critical flexhoses identified in this system.

### 1.7 CRITICAL ORIFICES

There were no critical orifices identified in this system.

### 1.8 CRITICAL FILTERS

There were no critical filters identified in this system.

### 1.9 END-TO-END AREAS OF CONCERN

The following areas of concern were identified:

- a. The mobile crane has an audio/visual anti-two block system that alerts the operator that a two block situation (hook block or ball contacting the sheaves of the boom head machinery) is imminent. The system is activated when the hook ball or block contacts a suspended weight. The operator stops hoisting to prevent the two block situation. This system is not the same as the one upper limit switch to prevent two blocking as required by paragraph 3.2.6.F of NSS/GO-1740.9 dated July 1988. See section 6.2 for details.

### 1.10 SNEAK CIRCUITS IDENTIFIED

There was no Sneak Circuit Analysis performed on this system.

### 1.11 RECOMMENDATIONS

The risk associated with the Critical Items identified in section 3.0 should be accepted by management based on the acceptance rationale provided on the CIL Sheets.

### 1.12 CRITICALITY CATEGORY 1R STAR (1R\*) ITEMS

There were no criticality category 1R\* items identified during the analysis of the critical output functions identified in section 2.4 for this equipment.

## 2.0 FAILURE MODE AND EFFECTS ANALYSIS

### 2.1 SYSTEM BASELINE

This system is baselined for STS by 79K09579, 8-17-88, "KSC STS/Cargo Identification List for Facilities, Systems, and Equipment by Baseline

Number." The OMD Baseline No. is 330.00. "System Documentation List" 79K11010 establishes the system baseline configuration.

## 2.2 GROUND RULES/DEFINITIONS/DOCUMENTATION

2.2.1 GROUND RULES. This analysis has been developed in accordance with NSTS 22206, Rev. B, "Instructions for Preparation of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)," and the following additional ground rules and assumptions:

- a. Criticality Category 1 applies to the critical items because of plans to use the 40-ton mobile crane to lift any load within the capability of the crane including flight hardware and/or GSE containing hazardous materials (e.g., the APU Fuel Cart at the launch pad).
- b. Passive components will not be analyzed in the FMEA. The current list of passive components includes the following:

<u>Item</u>	<u>Find No.</u>	<u>Dwg. No.</u>
<u>Mechanical Passive Components</u>		
Hook Ball & Swivel Socket & Wedge	46M0623 8Y0004 1Y0087	PM 18-4-14.0 PM 16-5-19.0
Wire Rope Spec. 990704366	NA	PM 16-5-23.0
4 Sheave Head Machinery	NA	PM 17-9-32.0
Boom Tip Section	NA	PM 17-1-84.0
Boom Inner Mid Section	NA	PM 17-1-84.0
Boom Base Section	NA	PM 17-1-84.0
Fly (Boom Extension)	46M0566	PM 17-10-53.0
Upper Revolving Frame and Turntable	NA	PM 3-1-111.0
Counterweight	57B0062	PM 3-3-85.0
Chassis	NA	NA
Locomotion Components (transmission, drive shaft, axles, tires, suspension)	NA	NA
Winch Frame	57D0052	PM 5-4-82.0

<u>Item</u>	<u>Find No.</u>	<u>Dwg. No.</u>
<u>Hydraulic Passive Components</u>		
Rotating Joint	53J0115	PM 1-48-80.01
Hydraulic Reservoir	53J0085	PM 1-39-47.01
Oil Cooler	46A0974	PM 1-75-135.00

#### 2.2.1.1 Failure of Redundant Items and Redundant Item Screens.

2.2.1.1.1 Failure of Redundant Items. The combined effect of failure for two like and/or unlike redundant items which could result in loss of life/vehicle will be analyzed. Failure of redundant items with possible Criticality Category 1 effects will be classified as 1R Star (1R\*) items. Failures within the system power and controls which could cause loss of either one of the redundant hardware items will be listed as the cause(s) for the failure of the redundant hardware items. Requirements for periodic validation of these 1R\* items will be invoked through the OMRS File VI. See section 9.0 for additional information.

2.2.1.1.2 Redundant Item Screens. Identified 1R\* items will be evaluated in section 9.0 in accordance with the redundancy screens described below. The Redundancy Screens are:

Screen A - The redundant item is capable of being checked and verified during normal ground operations.

Screen B - Loss of the redundant item is readily detectable by the ground crew. (This screen is not applicable to standby redundancy.)

Screen C - Loss of all redundant items cannot result from a single credible cause, such as contamination.

2.2.2 DEFINITIONS OF CRITICALITY AND HAZARD CATEGORIES. The following criticality and hazard categories were used throughout this analysis.

2.2.2.1 Criticality Definitions and Categories. Criticality definitions and categories are defined as follows:

<u>Category</u>	<u>Definitions</u>
1	A single failure that could cause loss of life or vehicle.
1R*	A single failure that when coupled with the failure of a like or unlike redundant hardware item could cause loss of life or vehicle.

<u>Category</u>	<u>Definitions</u>
1S	A single failure in a safety or hazard monitoring system that could cause the system to fail to detect, combat, or operate when needed during the existence of a hazardous condition and could result in loss of life or vehicle.
2	A single failure that could cause loss (damage) of a vehicle system.
3	All others.

Cause - Major reason or event that produces a failure mode.

Critical Equipment/System - Ground Support Equipment/Facility Systems are assessed as critical if loss of overall system function or improper performance of a system function could result in the loss of life, loss of vehicle, or damage to a vehicle system.

Critical Item - A critical item is defined as a Criticality Category 1, 1S, or 2 Single Failure Point.

Criticality Assessment - An analysis of each system function to determine if loss or improper performance of the function could result in a critical or noncritical effect.

Like Redundancy - Similar hardware items performing the same function.

Unlike Redundancy - Non-identical items performing the same function.

2.2.2.2 Hazard Categories. Hazard categories have been defined as follows:

Hazard - The presence of a potential risk situation caused by an unsafe act or condition.

Hazard Analysis - The determination of potential sources of danger and recommended resolutions in a timely manner for those conditions found in either the hardware/software systems, the person-machine relationship, or both, which cause loss of personnel capability, loss of system, or loss of life or injury to the public.

Hazard Report Closure Classification.

- a. Eliminated Hazard - A hazard that has been eliminated by removing the hazard source or by deleting the hazardous operations.
- b. Controlled Hazard - The likelihood of occurrence has been reduced to an acceptable level by implementing the appropriate hazard reduction precedence sequence to comply with program requirements.

- c. Accepted Risk - Hazard which has not been counteracted by redundancy purge provisions, appropriate safety factors, containment/isolation provision, backup system/operation, safety devices, alarm/caution and warning devices, or special automatic/manual procedures. Catastrophic hazards, critical hazards, hazards resulting from failure to meet program requirements, and Single Failure Points (SFPs) in emergency systems will be documented. A hazard will be classified as an "accepted risk" only after (1) all reasonable risk avoidance measures have been identified, studied, and documented; (2) project/program management has made a decision to accept the risk on the basis of documented risk acceptance rationale; and (3) Safety management has concurred in the accepted risk rationale.

Hazard Levels - The hazard level assigned to the identified hazard prior to applying the Hazard Reduction Precedence Sequence (HRPS) corrective action. Include hazard carried over for tracing from previous phases:

- a. Catastrophic - No time or means are available for corrective action.
- b. Critical - May be counteracted by emergency action performed in a timely manner.
- c. Controlled - Has been countered by appropriate design, safety devices, alarm/caution and warning devices, or special automatic/manual procedures.

Hazard Report Status.

- a. Closed - Corrective action to eliminate or control the hazard is completed, evaluated, and verified and management actions to accept the safety risks are completed. Actions taken, organization which performed actions and completion dates are to be documented in this data element.
- b. Open - Corrective action evaluation and verification is in progress. The status shall remain open until management has reviewed the actions taken and accepted the safety risk. Actions required, organization responsible for performing the actions and due dates are to be documented in this data element.

2.2.3 DOCUMENTATION LIST. The following documents were used in completing this analysis:

<u>Document/Drawing No.</u>	<u>Rev.</u>	<u>Outstanding EOs</u>	<u>Title</u>
NSTS 22254	—	—	Methodology for Conduct of NSTS Hazard Analysis
29 CFR 1910	—	—	OSHA Standards

<u>Document/Drawing No.</u>	<u>Rev.</u>	<u>Outstanding EOs</u>	<u>Title</u>
NSTS 22206	B	-	Instructions for Preparation of Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)
NSS/GO-1740.9	July 1988		NASA Safety Standard for Lifting Devices and Equipment
Book No. 647	-	-	Operator's Maintenance Manual, Model HSP-8040, Serial No. 53H7-0816, Link-Belt Construction Equipment
Book No. 699	-	-	Shop Manual, Model HSP-8040, Serial No. 53H7-0816, Link-Belt Construction Equipment
RT-ENG-2/89-97	-	-	The KSC Approach to Ground Support Equipment Failure Modes and Effects Analysis (FMEAs)
RT-ENG-2/89-65	-	-	The KSC Approach to Ground Support Equipment Failure Modes and Effects Analysis (FMEAs) With Redlined NSTS 22206 Rev. B.

NOTE: Drawing numbers in this SAA that are prefixed by the letters "PM," such as PM 5-4-62.0, are from the Link-Belt Parts Manual.

Book No. N/A	Parts Manual, Model HSP-8040, Serial No. 53H7-0816, Link-Belt Construction Equipment
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NOTE: Drawing numbers in this SAA that are prefixed by the letters "SM," such as SM 7-0-71.0, are from the Link-Belt Shop Manual.

SM7-0-71.0	Main Hydraulic System Diagram - Upper, Figure 1, Link-Belt Construction Equipment
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## 2.3 SYSTEM DESCRIPTION

The Link-Belt 40-Ton Mobile Crane, Model HSP-8040, is used at KSC in support of the Shuttle program at the contingency landing sites and other station sets for general critical lifts.

The crane consists of a chasis and upperstructure. The upperstructure is mounted on the chasis by means of a turntable. This allows the upperstructure to rotate on a single axis above the chasis. A boom mounted on the upperstructure may be raised, lowered, and positioned horizontally along with any load suspended from it. The load is positioned vertically by means of a hoisting system.

### Upperstructure

- Boom - Three section boom measuring 35'-0" closed and 85'-0" extended. Equipped with boom length/angle indicator and anti-two block system.
- Cab and Controls - Control levers for (1) raising and lowering the boom, (2) raising and lowering the load with the hoist, (3) extending or retracting the middle telescoping cylinder for the boom, (4) extending or retracting the tip telescoping cylinder for the boom, and (5) swing lever for rotating the upperstructure. There are foot controls for (1) the swing brake and (2) additional foot control for boom raising and lowering.
- Swing - Bi-directional hydraulic swing motor mounted to a planetary reducer for 360 deg. continuous smooth swing at 2.45 rpm.
- Swing brake - Manually applied spring released, disc brake mounted on the swing speed reducer.
- Swing lock - 360 deg. position and a two position travel lock operated from the operator's cab.
- Hydraulic system - Main pump of tandem, triple gear design powered by a torque converter through a pump disconnect. Steering/outrigger pump of single gear type design powered by a torque converter through a straight mechanical drive. The reservoir of 140 U.S. gallon capacity contains a return line filter mounted at the fill port and has diffusers for deaeration. There are five separate control valves allowing simultaneous operation of all crane functions. This is a 3000 PSI pressure system.
- Load hoist system - Rear winch mounted at end of counterweight beam with two-speed motor and automatic brake. Has power up/power down mode of operation. Bi-directional gear type hydraulic motor. Maximum available line pull of 15,870 lbs., and a maximum line speed of 548 fpm.

Electrical system - There are six categories of circuits that make up the electrical system.

- 1.) Primary Power.
- 2.) Engine and Transmission Controls - For starting, transmission shift select, and ether injector.
- 3.) Monitoring Group - For engine, transmission, hydraulic system, axle and park brake indicators and instrument power (anti-two block system and boom length/boom angle indicator).
- 4.) Lights and Horns.
- 5.) Equipment Controls - For outriggers, hoist axle oscillation steering, 4-wheel drive, and park brake controls.
- 6.) Accessories - For heater, defroster, windshield wipers, etc.

Air System - There are three areas the compressed air system serves.

- 1.) Brakes - For air over hydraulic pressure convertors for the brakes, stop light switch, and low air pressure switch.
- 2.) Throttle - For throttle lock and throttle control cylinder.
- 3.) Hoist shift - For the two speed hoist shift.

Anti-Two Block System - This is an audio/visual system that alerts the operator that a two block situation (hook block or ball contacting the sheaves of the boom head machinery) is imminent. The system is activated, a light will illuminate and a horn will sound, when the hook ball or block contacts a suspended weight. The operator stops hoisting to prevent the two block situation. The warning devices are integral with the boom length/boom angle indicator unit.

Boom Length/Boom Angle Indicator - This is a programmable audio/visual system that constantly displays either boom angle or boom length as requested and displays and sounds an alarm (horn) when the minimum or maximum parameters are attained. The warning devices for the anti-two block system are integral with this unit.

### Chassis

Frame - Welded steel construction.

Axles - Planetary drive steer type, both front and rear.

Service brakes - Air over hydraulic, drum type on each wheel.

Steering - Hydraulic two wheel, four wheel and "crab" steering.

Transmission - Power shift transmission with front wheel disconnect for 2 or 4-wheel drive.

Outriggers - Four hydraulic, beam and jack outriggers. Vertical jack cylinders equipped with integral holding valve. Equipped with stowable, lightweight floats.

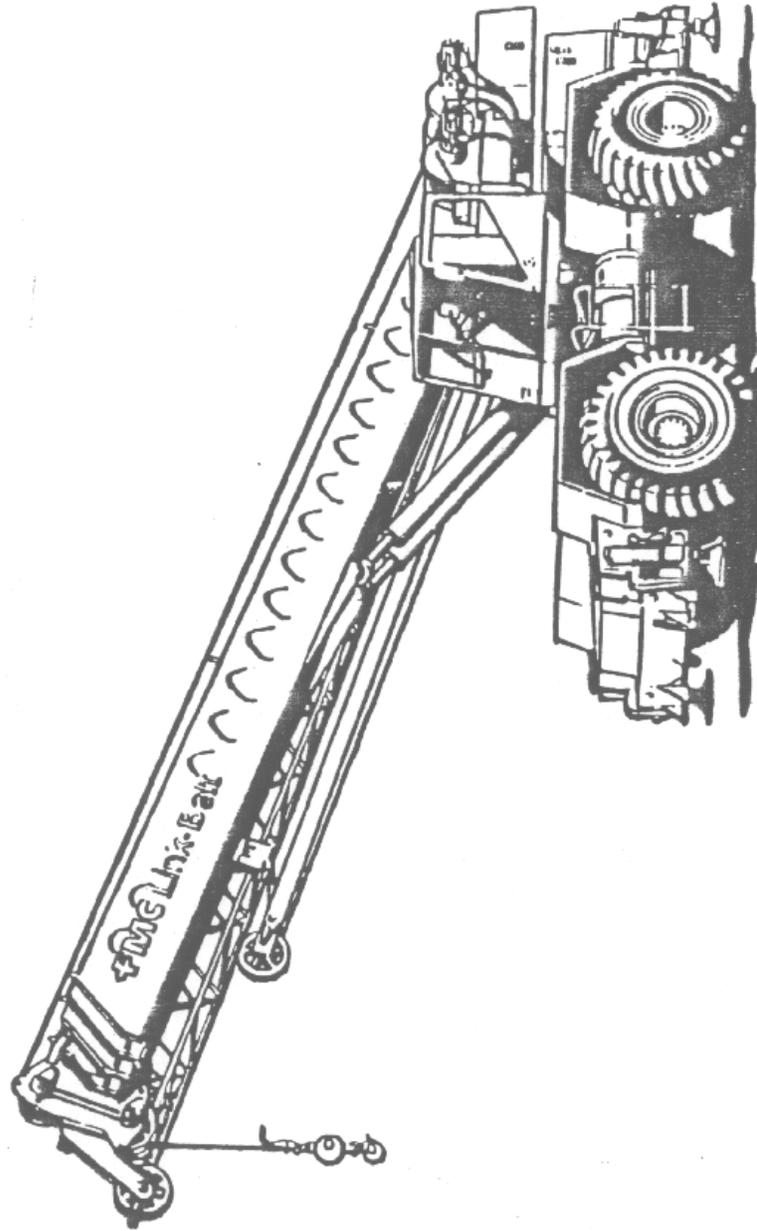


Fig. 1. Link-Belt 40-Ton Mobile Crane, Model HSP-8040.

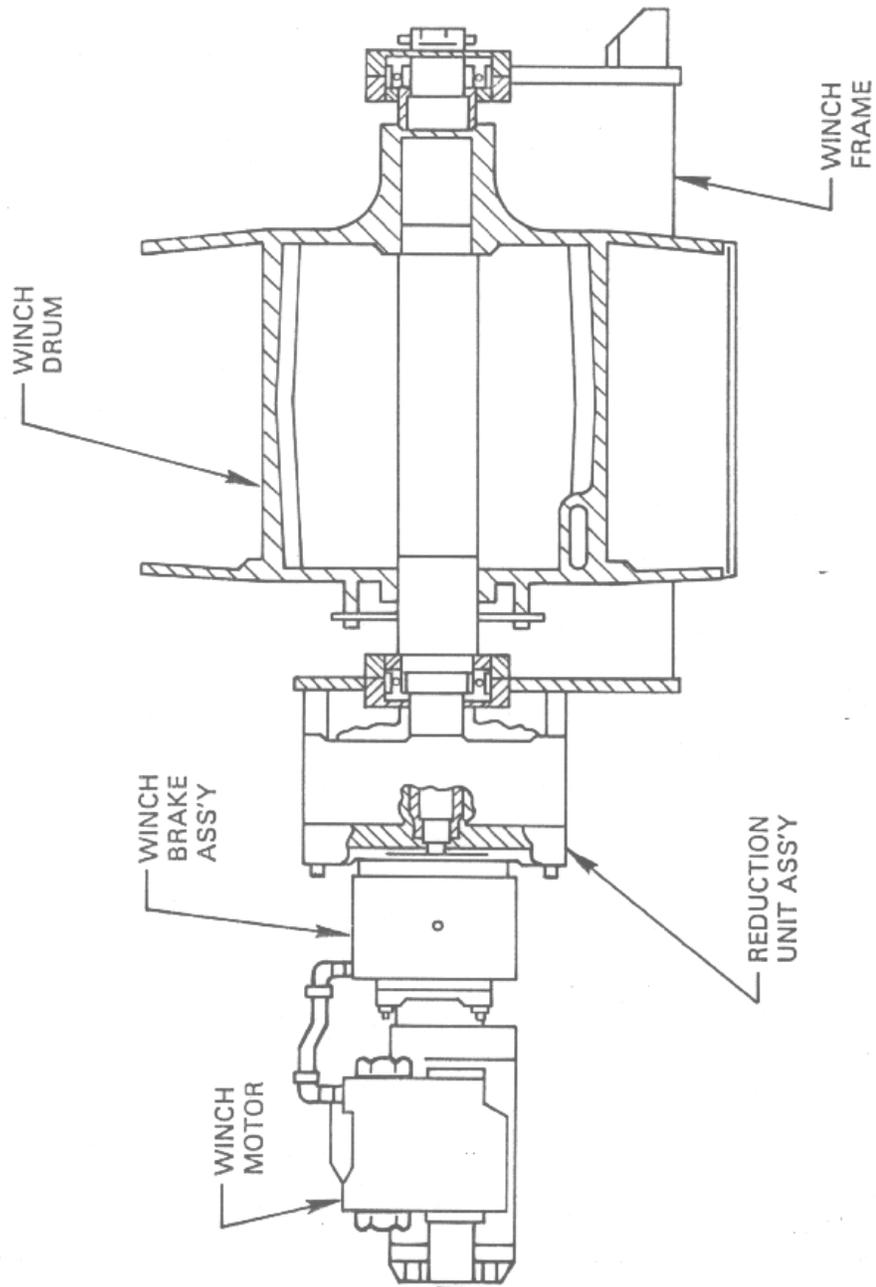


FIGURE 2. WINCH DRUM AND WINCH DRIVE ASS'Y

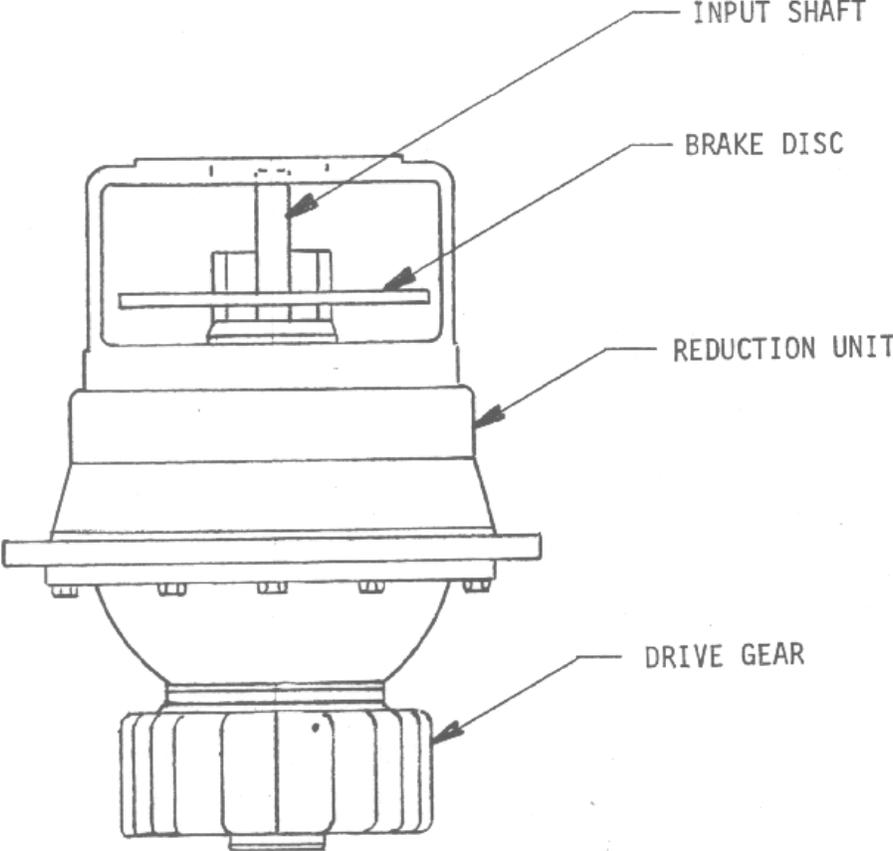


FIGURE 3. SWING SPEED REDUCER ASSEMBLY

## 2.4 SYSTEM CRITICALITY ASSESSMENT

The system functions are identified in figure 3, System Functional Block Diagram, and assessed on the following Criticality Assessment Summary Sheets (form 21-375a).

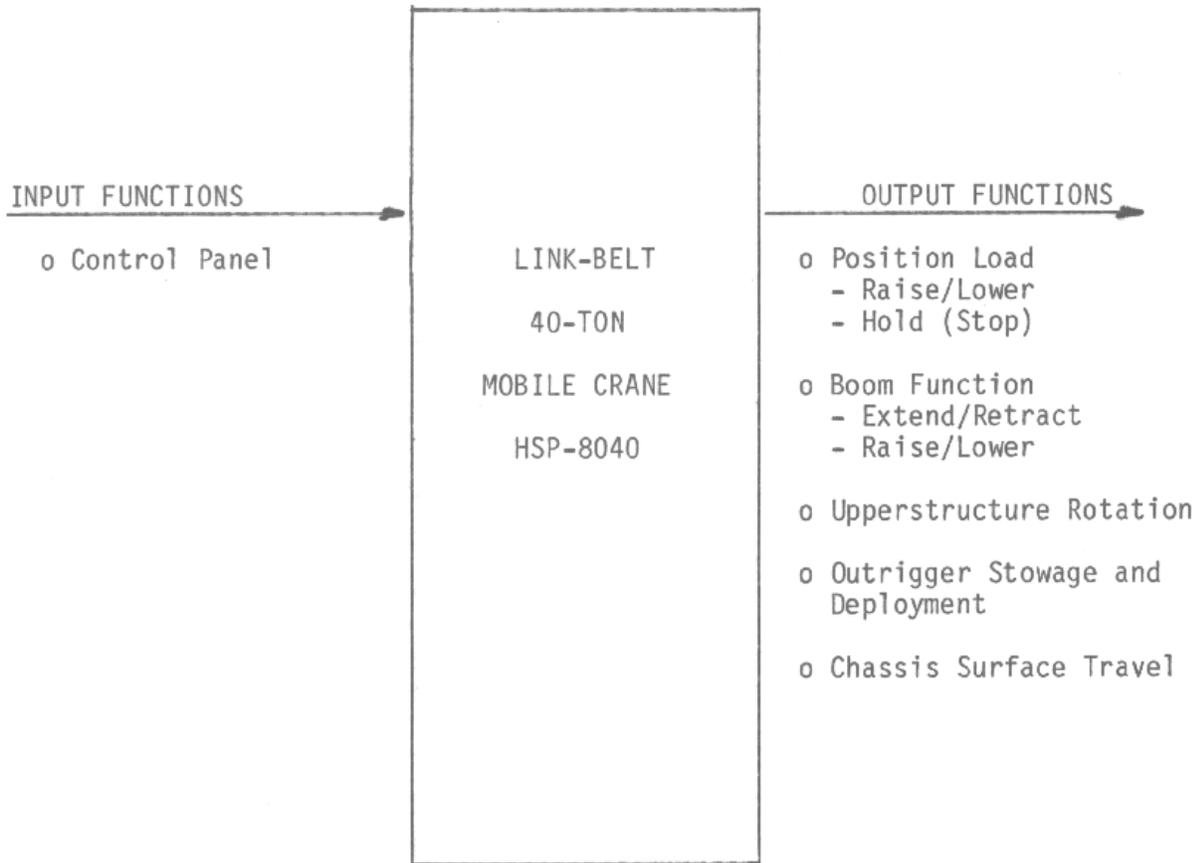


Figure 4. Link-Belt 40-Ton Mobile Crane HSP-8040 System Functional Block Diagram

SYSTEM CRITICALITY ASSESSMENT SUMMARY SHEET				SHEET 1 OF 2	
PROGRAM MODEL NO.	SYSTEM/SUBSYSTEM	STATION SET (NAME AND NUMBER)	SCHEMATIC DRAWING NO.		
H72-1394	LINK-BELT 40-TON MOBILE CRANE	MULTIPLE STATION SETS/99	LINK-BELT O&M MANUAL BOOK NO. 647, FIGURE 1.1		
BASELINE	LOCATION	PREPARED BY	DATE		
330.00	KSC	R. BRINSMADE, LSOC 51-22	JUNE 1989		
INPUT/OUTPUT	FUNCTION	TIME PERIOD	EFFECT OF LOSS/FAILURE	CRIT CAT	NOTES
<b>INPUT FUNCTIONS</b>					
o CONTROL PANEL	PROVIDES OPERATOR WITH THE MEANS OF OPERATING THE CRANE.	GENERAL SUPPORT	LOSS OR FAILURE OF THE CONTROL PANEL COULD ALLOW THE LOAD TO DROP AND/OR IMPACT OTHER HARDWARE AND CAUSE RELEASE OF TOXIC MATERIALS, AND/OR FIRE/EXPLOSION OF PROPELLANTS RESULTING IN POSSIBLE LOSS OF LIFE, VEHICLE OR LOSS (DAMAGE) TO A VEHICLE SYSTEM.	C	
<b>OUTPUT FUNCTIONS</b>					
o POSITION LOAD	PROVIDE VERTICLE MOVEMENT OF THE LOAD.	GENERAL SUPPORT	DELAY IN OPERATION.	N/C	
- HOLD (STOP)	SUPPORT THE LOAD IN A FIXED POSITION.	GENERAL SUPPORT	LOAD COULD DROP AND CAUSE RELEASE OF TOXIC MATERIALS, AND/OR FIRE/EXPLOSION OF PROPELLANTS RESULTING IN POSSIBLE LOSS OF LIFE, VEHICLE OR LOSS (DAMAGE) TO A VEHICLE SYSTEM.	C	SEE FMEA.
o BOOM FUNCTION	PROVIDE HORIZONTAL POSITIONING OF THE LOAD.	GENERAL SUPPORT	LOAD COULD IMPACT OTHER HARDWARE RESULTING IN POSSIBLE DAMAGE TO FLIGHT HARDWARE.	C	SEE FMEA.

SYSTEM CRITICALITY ASSESSMENT SUMMARY SHEET				SHEET 2 OF 2
PROGRAM MODEL NO.	SYSTEM/SUBSYSTEM	STATION SET (NAME AND NUMBER)	SCHEMATIC DRAWING NO.	
H72-1394	LINK-BELT 40-TON MOBILE CRANE	MULTIPLE STATION SETS/99	LINK-BELT O&M MANUAL BOOK NO. 647, FIGURE 1.1	
BASELINE	LOCATION	PREPARED BY	DATE	
330.00	KSC	R. BRINSMADE, L50C 51-22	JUNE 1989	
INPUT/OUTPUT	FUNCTION	TIME PERIOD	EFFECT OF LOSS/FAILURE	CRIT CAT
o UPPERSTRUCTURE ROTATION	PROVIDE RADIAL MOVEMENT OF THE LOAD.	GENERAL SUPPORT	FAILURE OF THE UPPERSTRUCTURE TO STOP ROTATING COULD ALLOW THE LOAD TO IMPACT OTHER HARDWARE RESULTING IN POSSIBLE DAMAGE TO FLIGHT HARDWARE.	C
o OUTRIGGER STORAGE AND DEPLOYMENT	DEPLOYED OUTRIGGERS PROVIDE STABILITY TO THE CRANE.	GENERAL SUPPORT	FAILURE OF AN OUTRIGGER TO SUPPORT COULD ALLOW THE LOAD TO SHIFT AND/OR THE CRANE TO OVERTURN IMPACTING THE LOAD AND CAUSING RELEASE OF TOXIC MATERIALS, AND/OR FIRE/EXPLOSION OF PROPELLANTS RESULTING IN POSSIBLE LOSS OF LIFE, VEHICLE OR LOSS (DAMAGE) TO A VEHICLE SYSTEM.	C
o CHASSIS SURFACE TRAVEL	MOVE THE CRANE TO THE LIFT SITE.	GENERAL SUPPORT	DELAY IN OPERATION.	N/C
				ALL CRITICAL LIFTS ARE PERFORMED WITH THE OUTRIGGER DEPLOYED.

## 2.5 MECHANICAL FMEA WORKSHEETS AND BLOCK DIAGRAMS

The mechanical components of this system are identified from the documents and diagrams referenced in the Documentation List and are analyzed on the following FMEA worksheets (form 21-232a).

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SAA09FT01-006

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HOISTING LINK-BELT Page 1 of 2 Date JUNE 1989  
 Drawing No. PM5-4-62.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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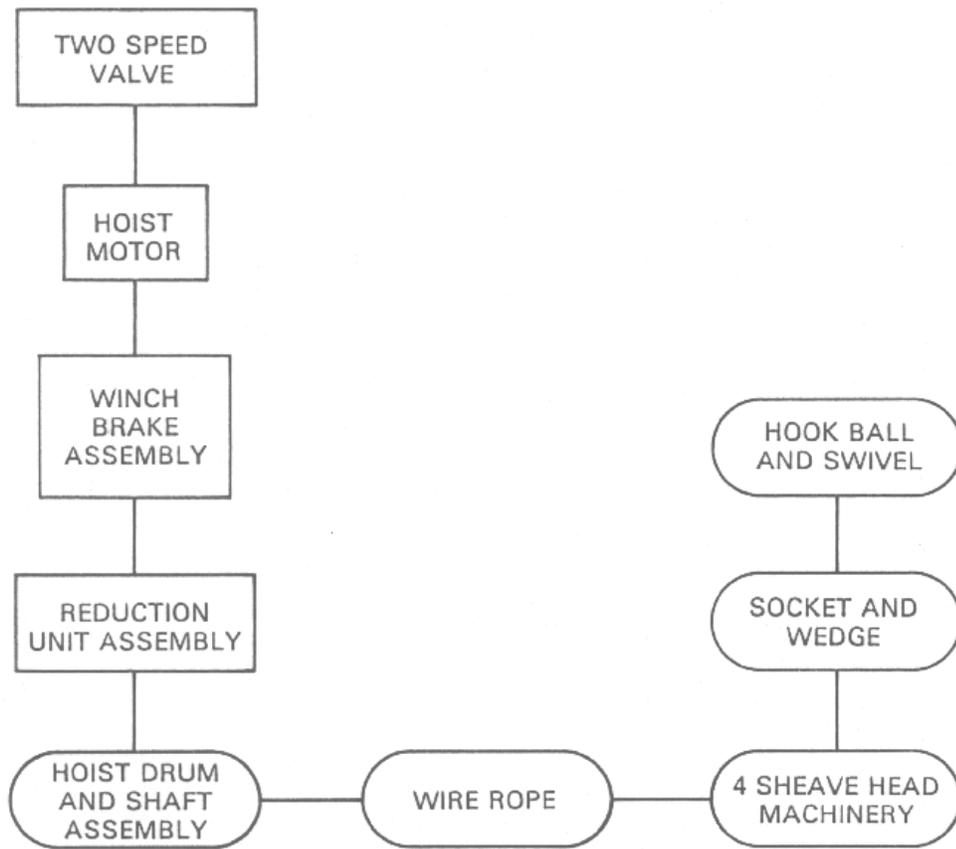
46D0102 REDUCTION UNIT TRANSFERS TORQUE FROM THE WINCH DRIVE HYDRAULIC MOTOR TO THE WINCH DRUM.  
 ASSEMBLY (PM5-7-74.0)  
 A. GEARS DISENGAGE TORQUE FOR HOLDING LOAD WILL BE LOST. LOAD SUSPENDED FROM HOOK MAY DROP.  
 B. STRUCTURAL FAILURE  
 C. FM NO. 09FT01-006.001  
 D. VISUAL  
 E. NONE  
 F. SECONDS  
 G. N/A  
 POSSIBLE LOSS OF LIFE OR VEHICLE OR LOSS (DAMAGE) TO A VEHICLE SYSTEM.  
 NOTE: THE WORST CASE OF CRITICALITY CATEGORY 1 APPLIES BECAUSE OF PLANS TO USE THE 40-TON MOBILE CRANE TO LIFT ANY LOAD WITHIN THE CAPABILITY OF THE CRANE INCLUDING FLIGHT HARDWARE AND/OR GSE CONTAINING HAZARDOUS MATERIALS.

53D0098 WINCH BRAKE PREVENTS ROTATION OF WINCH DRUM WHEN WINCH DRIVE HYDRAULIC MOTOR IS NOT OPERATING AND WHEN LOAD IS SUSPENDED.  
 ASSEMBLY (PM5-12-124.0)  
 A. BRAKE SLIPS OR FAILS TO ENGAGE TORQUE FOR HOLDING LOAD WILL BE LOST. LOAD SUSPENDED FROM HOOK MAY DROP.  
 B. STRUCTURAL FAILURE  
 C. FM NO. 09FT01-006.002  
 D. VISUAL  
 E. NONE  
 F. SECONDS  
 G. N/A  
 POSSIBLE LOSS OF LIFE OR VEHICLE OR LOSS (DAMAGE) TO A VEHICLE SYSTEM.  
 NOTE: THE WORST CASE OF CRITICALITY CATEGORY 1 APPLIES BECAUSE OF PLANS TO USE THE 40-TON MOBILE CRANE TO LIFT ANY LOAD WITHIN THE CAPABILITY OF THE CRANE INCLUDING FLIGHT HARDWARE AND/OR GSE CONTAINING HAZARDOUS MATERIALS.

1X4286 BEARING SUPPORTS AND ALLOWS ROTATION OF THE DRUM SHAFT END NEXT TO THE REDUCTION UNIT ASSEMBLY.  
 (DRUM SHAFT) (PM5-4-82.0)  
 A. DRUM SHAFT WILL NOT TURN. DRUM SHAFT WILL NOT TURN. DELAY IN OPERATIONS.  
 B. BEARING SEIZES  
 NO EFFECT.  
 3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System	LINK-BELT 40-TON MOBILE CRANE			Facility or Station Set	MULTIPLE SS/99	
Subsystem	MECHANICAL - HOISTING LINK-BELT			Page	2	of 2
Drawing No.	PM5-4-62.0	Sheet No.		Date	JUNE 1989	
PMN	H72-1394			Prepared By	R. BRINSMADE, LSOC 51-22	
FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
1X2306	BEARING (DRUM SHAFT) (PM5-4-82.0)	SUPPORTS AND ALLOWS ROTATION OF THE DRUM SHAFT END OPPOSITE TO THE REDUCTION UNIT ASSEMBLY.	A. DRUM SHAFT WILL NOT TURN B. BEARING SEIZES	DRUM SHAFT WILL NOT TURN. DELAY IN OPERATIONS.	NO EFFECT.	3



LEGEND:

- ACTIVE
- PASSIVE

Figure 5. Hoist System Block Diagram

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - SWING LINK-BELT Page 1 of 1 Date JUNE 1989  
 Drawing No.                      Sheet No.                      Program SPACE SHUTTLE  
 PMN                      Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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46F0085	SWING SPEED REDUCER (PM4-10-17.0)	TRANSFERS TORQUE FROM THE SWING DRIVE HYDRAULIC MOTOR TO THE TURN-TABLE ASSEMBLY.	A. GEARS DISENGAGE B. STRUCTURAL FAILURE C. 09FT01-006.003 D. VISUAL E. APPLICATION BY OPERATOR OF SWING BRAKE TO CONTROL AND STOP HORIZONTAL ROTATION OF UPPERSTRUCTURE F. SECONDS G. N/A	TORQUE FOR CONTROLLING HORIZONTAL ROTATION OF UPPER-STRUCTURE WILL BE LOST. LOAD MAY IMPACT OTHER HARDWARE RESULTING IN DAMAGE TO FLIGHT HARDWARE.	POSSIBLE LOSS (DAMAGE) TO A VEHICLE SYSTEM.	2
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46F0141	SWING BRAKE ASSEMBLY (PM4-5-61.0)	SLOWS AND STOPS ROTATION OF UPPER-STRUCTURE WHEN SWING DRIVE HYDRAULIC MOTOR IS NOT POWERED.	A. BRAKE SLIPS OR FAILS TO ENGAGE B. MISADJUSTED BRAKE OR STRUCTURAL FAILURE C. NA D. VISUAL E. OPERATOR CAN CORRECT WITH REVERSING ACTION PROCEDURES F. SECONDS G. N/A	TORQUE FOR SLOWING HORIZONTAL ROTATION AND HOLDING UPPER-STRUCTURE IN POSITION WILL BE LOST. LIMITED SPEED OF SWING, FRICTION, AND REVERSING PROCEDURES WILL PREVENT DAMAGE. DELAY IN OPERATIONS.	NO EFFECT.	3
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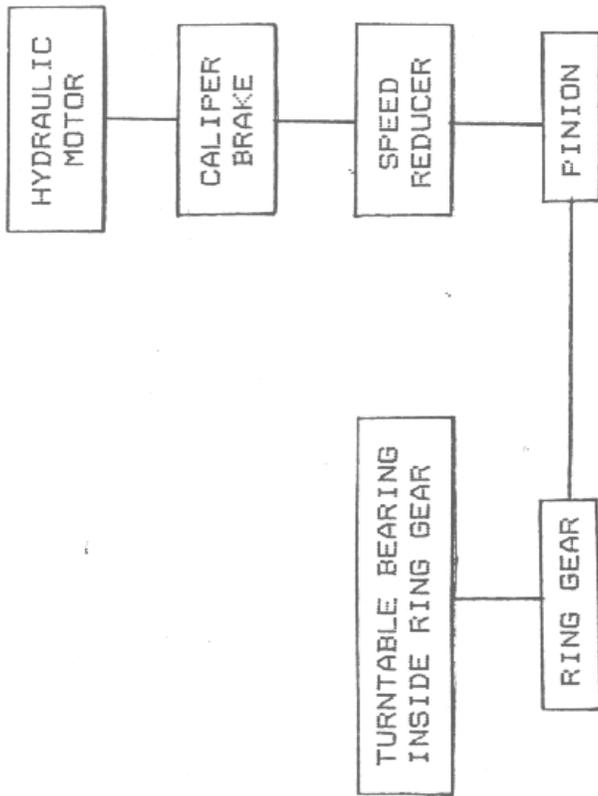


Figure 6. Swing Reducer and Brake Block Diagram

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT  
 Drawing No. SM7-0-71.0 Sheet No. 4  
 PMN H72-1394

Facility or Station Set MULTIPLE SS/99  
 Page 1 of 20 Date JUNE 1989  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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46J1193 PUMP ASSEMBLY (PM1-81-17.0) PROVIDES MOTIVE FORCE FOR WINCH, BOOM TELESCOPING CYLINDERS, UPPER-STRUCTURE SWING MOTOR, AND BOOM HOIST (RAISE AND LOWER) CYLINDERS.  
 A. FAILS TO OPERATE  
 B. MECHANICAL FAILURE  
 SYSTEMS INOPERATIVE. DELAY IN OPERATIONS. NO EFFECT. 3

58J0439 CONTROL VALVE, 4-SECTION, 4-WAY SWING/TELESCOPE PM7-8-236.0 PROVIDES MOVEMENT CONTROL FOR UPPER-STRUCTURE SWING MOTOR AND BOOM TELESCOPING CYLINDERS.  
 A. FAILS OPEN  
 B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION IN VALVE  
 C. NA  
 D. VISUAL  
 E. OPERATOR CAN CUT OFF HYDRAULIC POWER BY TURNING OFF THE ENGINE IGNITION SWITCH.  
 F. SECONDS  
 G. IMMEDIATE  
 FUNCTION(S) SELECTED WILL OPERATE UNIMPEDED. DELAY IN OPERATIONS. NO EFFECT. 3

A. FAILS CLOSED  
 B. MECHANICAL FAILURE  
 APPROPRIATE SECTIONS(S) OF THE 4-WAY VALVE INOPERATIVE. DELAY IN OPERATIONS. NO EFFECT. 3

SAA09FT01-006

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 2 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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46J1237 HYDRAULIC MOTOR, SWING  
 SWINGS UPPER-STRUCTURE 360 DEG. VIA SWING SPEED REDUCER ASSEMBLY.  
 A. FAILS TO OPERATE  
 B. MECHANICAL FAILURE  
 UPPERSTRUCTURE SWING DRIVE INOPERATIVE. DELAY IN OPERATIONS.  
 NO EFFECT.  
 3

57J0564 CYLINDER, INNER MID TELESCOPE (PM17-2-82.0)  
 EXTENDS AND RETRACTS INNER MID SECTION OF BOOM.  
 A. ROD SEAL RUPTURE/TEAR  
 B. EXCESSIVE PRESSURE/CONTAMINATION  
 OIL LEAK. THE MAJORITY OF HOISTING OPERATIONS REQUIRE THAT THE BOOM BE IN THE RAISED POSITION. GRAVITATIONAL CONSTRAINT PRECLUDES EXTENSION OF CYLINDER. DELAY IN OPERATIONS.  
 NO EFFECT.  
 3

A. CYLINDER INTERNAL LEAK  
 B. SEAL WEAR  
 C. NA  
 D. VISUAL  
 E. OPERATOR CAN APPLY EXTEND PRESSURE TO COUNTER RETRACT LEAK AND/OR MANEUVER OUT OF CRITICAL SITUATION.  
 F. SECONDS  
 G. IMMEDIATE  
 FAILURE OF THE SEAL RING WILL ALLOW THE CYLINDER TO BLEED DOWN. DELAY IN OPERATIONS.  
 NO EFFECT.  
 3



FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 4 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.          Program SPACE SHUTTLE  
 PWN H72-1394 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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57J0564  
(CONT'D)

A. CYLINDER INTERNAL LEAK  
 B. SEAL LEAK  
 C. NA  
 D. VISUAL  
 E. OPERATOR CAN APPLY EXTEND PRESSURE TO COUNTER RETRACT LEAK AND/OR MANEUVER OUT OF A CRITICAL SITUATION.  
 F. SECONDS  
 G. IMMEDIATE

3

FAILURE OF THE SEAL RING WILL ALLOW THE CYLINDER TO BLEED DOWN. DELAY IN OPERATIONS.

NO EFFECT.

36J0359

HOLDING VALVE MAINTAINS CYLINDER PRESSURIZED IN THE EXTENDED POSITION.  
 FOR OUTER MID TELESCOPE (PM7-8-151.0)

NO EFFECT.

3

NO EFFECT. CONTROL VALVE IN THE NEUTRAL (CLOSED) POSITION PROVIDES REDUNDANCY TO HOLD THE CYLINDER. DELAY IN OPERATIONS.

3

NO EFFECT

OUTER MID TELESCOPE CYLINDER WILL NOT BE ABLE TO EXTEND OR RETRACT WHEN SWING/TELESCOPE CONTROL VALVE IS MOVED TO EXTEND OR RETRACT BOOM. DELAY IN OPERATIONS.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 5 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.           
 PMN H72-1394

Program SPACE SHUTTLE

Prepared By R. BRINSMAD, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FWN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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46J1646 CONTROL VALVE, PROVIDES MOVEMENT FUNCTION SELECTED WILL NO EFFECT. 3  
 1-SECTION, 4- CONTROL FOR BOOM OPERATE UNIMPEDED. DELAY  
 WAY (BOOM) HOIST CYLINDERS. IN OPERATIONS.  
 (PM7-8-220.0)

- A. FAILS OPEN
- B. MECHANICAL FAILURE;  
RUPTURED OR DAMAGED  
SEALS; DIRT AND/OR  
CONTAMINATION IN  
VALVE
- C. NA
- D. VISUAL
- E. OPERATOR CAN CUT OFF  
POWER, SAFING THE  
SYSTEM
- F. SECONDS
- G. IMMEDIATE

53J0130 (2 EACH) HOLDING VALVE MAINTAINS CYLIN- NO EFFECT. 3  
 FOR BOOM HOIST DERS PRESSURIZED  
 CYLINDERS IN THE EXTENDED  
 (PM17-3-89.0) POSITION.

- A. FAILS CLOSED
- B. MECHANICAL FAILURE
- A. FAILS OPEN
- B. MECHANICAL FAILURE;  
RUPTURED OR DAMAGED  
SEALS; DIRT AND/OR  
CONTAMINATION IN  
VALVE

SECTION OF THE 4-WAY VALVE  
 INOPERATIVE. DELAY IN  
 OPERATION.

NO EFFECT. CONTROL VALVE  
 IN THE NEUTRAL (CLOSED)  
 POSITION PROVIDES REDUNDANCY  
 TO HOLD THE CYLINDER. DELAY  
 IN OPERATIONS.

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 6 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.          Program SPACE SHUTTLE  
 PWN H72-1394 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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53J0130  
(2 EACH)  
(CONT'D)

A. FAILS CLOSED  
 B. MECHANICAL FAILURE  
 BOOM HOIST CYLINDERS WILL NOT BE ABLE TO EXTEND OR RETRACT WHEN BOOM HOIST CONTROL VALVE IS MOVED TO RAISE OR LOWER THE BOOM. DELAY IN OPERATIONS.  
 NO EFFECT.

3

57J0563

BOOM HOIST  
 CYLINDER,  
 RIGHT  
 (PM 17-3-69.0)  
 AND LOWER LOAD BY  
 (1 EACH)  
 CHANGING ANGLE OF  
 BOOM WHEN THE  
 CYLINDER IS EX-  
 TENDED OR RE-  
 TRACTED.

A. ROD SEAL RUPTURE/  
 TEAR  
 B. EXCESSIVE PRESSURE/  
 CONTAMINATION  
 OIL LEAK WHEN ROD END OF CYLINDER BECOMES PRESSURIZED DURING RAISING OR LOWERING OF BOOM. REMAINING LEFT BOOM HOIST CYLINDER WILL ALLOW CONTROLLED LOWERING. DELAY IN OPERATIONS.  
 NO EFFECT.

3

57J0563

A. CYLINDER INTERNAL  
 LEAK  
 B. SEAL LEAK  
 C. N/A  
 D. VISUAL  
 E. OPERATOR CAN APPLY  
 EXTEND PRESSURE TO  
 COUNTER RETRACT LEAK  
 AND/OR MANEUVER OUT  
 OF CRITICAL SITUATION.  
 F. SECONDS  
 G. IMMEDIATE

FAILURE OF THE SEAL RING WILL ALLOW THE CYLINDER TO RETRACT. LIKE REDUNDANCY IS PROVIDED BY THE LEFT BOOM HOIST CYLINDER. DELAY IN OPERATIONS.  
 NO EFFECT.

3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 7 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.          Program SPACE SHUTTLE  
 PMN H72-1394 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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57J0563	BOOM HOIST CYLINDER, LEFT (PM 17-3-69.0) (1 EACH)	IN UNISON WITH THE LEFT BOOM HOIST CYLINDER, RAISE AND LOWER LOAD BY CHANGING ANGLE OF BOOM WHEN THE CYLINDER IS EXTENDED OR RETRACTED.	A. ROD SEAL RUPTURE/ TEAR B. EXCESSIVE PRESSURE/ CONTAMINATION	OIL LEAK WHEN ROD END OF CYLINDER BECOMES PRESSURIZED DURING RAISING OR LOWERING OF BOOM. REMAINING RIGHT BOOM HOIST CYLINDER WILL ALLOW CONTROLLED LOWERING. DELAY IN OPERATIONS.	NO EFFECT.	3
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			A. CYLINDER INTERNAL LEAK B. SEAL LEAK C. N/A D. VISUAL E. OPERATOR CAN APPLY EXTEND PRESSURE TO COUNTER RETRACT LEAK AND/OR MANEUVER OUT OF A CRITICAL SITUATION F. SECONDS G. IMMEDIATE	FAILURE OF THE SEAL RING WILL ALLOW THE CYLINDER TO RETRACT. LIKE REDUNDANCY IS PROVIDED BY THE RIGHT BOOM HOIST CYLINDER. DELAY IN OPERATIONS.	NO EFFECT.	3
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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 8 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.           
 Program SPACE SHUTTLE  
 Prepared By R. BRINSMAD, LSOC 51-22  
H72-1394

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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46J1646 CONTROL VALVE, PROVIDES MOVEMENT  
 2 SECTION, CONTROL FOR WINCH  
 4-WAY (HOIST) MOTOR.  
 (PM7-8-220.0)

A. FAILS OPEN  
 B. MECHANICAL FAILURE;  
 RUPTURED OR DAMAGED  
 SEALS; DIRT AND/OR  
 CONTAMINATION IN  
 VALVE  
 C. NA  
 D. VISUAL  
 E. OPERATOR CAN CUT OFF  
 POWER, SAFING THE  
 SYSTEM  
 F. SECONDS  
 G. IMMEDIATE

FUNCTION SELECTED WILL  
 OPERATE UNIMPEDED. DELAY  
 IN OPERATION.

3

A. FAILS CLOSED  
 B. MECHANICAL FAILURE

SECTION OF THE 4-WAY VALVE  
 INOPERATIVE. DELAY IN  
 OPERATION.

NO EFFECT. 3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 9 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No. H72-1394 Program SPACE SHUTTLE  
 PMN Prepared By R. BRINSMAD, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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53J0119	COUNTERBALANCE VALVE (PM7-8-216.0)	PREVENTS FREE-WHEELING OF THE WINCH HYDRAULIC MOTOR BY "LOCKING" OIL NEXT TO MOTOR WHEN CONTROL VALVE PLACED IN NEUTRAL AND WINCH HAS LOAD.	A. FAILS OPEN B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION IN VALVE C. NA D. VISUAL E. OPERATOR PLACES WINCH CONTROL VALVE IN NEUTRAL F. SECONDS G. IMMEDIATE	WINCH HYDRAULIC MOTOR WILL NOT OPERATE. WHEN OPERATOR PLACES WINCH CONTROL VALVE IN NEUTRAL THE AUTOMATIC BRAKE WILL BE APPLIED. DELAY IN OPERATIONS.	NO EFFECT.	3
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53J0118	HYDRAULIC MOTOR, WINCH (PM7-6-170.0)	DRIVES WINCH DRUM VIA PLANETARY REDUCTION UNIT ASSY.	A. FAILS TO OPERATE B. MECHANICAL FAILURE	WINCH HYDRAULIC MOTOR WILL NOT OPERATE. DELAY IN OPERATIONS.	NO EFFECT.	3
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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 10 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.          Program SPACE SHUTTLE  
 PMN H72-1394 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
46J0635	STEER CONTROL VALVE (PM7-22-16.0)	CONTROLS DIRECTION AND FLOW OF HYDRAULIC OIL TO STEERING CYLINDERS.	A. FAILS TO ROTATE B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION IN VALVE	STEERING SYSTEM INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
31J0382	CONTROL VALVE, SOLENOID OPERATED, 4-WAY, 2/4 WHEEL STEER (PM1-43-27.0)	USED TO SELECT 2, 4, OR CRAB STEERING.	A. FAILS OPEN B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION IN VALVE	FUNCTION SELECTED WILL OPERATE UNIMPEDED. NO CHANGE IN STEERING SELECTION POSSIBLE. DELAY IN OPERATIONS.	NO EFFECT.	3
46J1396 (4 EACH)	STEERING CYLINDERS (PM1-7-18.0)	PROVIDE STEERING, RIGHT AND LEFT.	A. FAILS CLOSED B. MECHANICAL FAILURE A. CYLINDER LEAKS INTERNALLY B. SEAL WEAR	SECTION OF VALVE INOPERATIVE. DELAY IN OPERATION. CYLINDER DOES NOT HOLD PRESSURE PROPERLY. REDUNDANT CYLINDER WILL PROVIDE STEERING UNLESS CRANE IS LOADED. DELAY IN OPERATIONS.	NO EFFECT. NO EFFECT.	3 3
			A. ROD SEAL RUPTURE/TEAR B. EXCESSIVE PRESSURE/CONTAMINATION	OIL LEAK. REDUNDANT CYLINDER WILL PROVIDE STEERING DEPENDING ON CRANE LOAD. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 11 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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46J1476 PUMP, OUT- PROVIDES MOTIVE A. FAILS TO OPERATE SYSTEMS INOPERATIVE. DELAY NO EFFECT. 3  
 RIGGER STEER- FORCE FOR OUT- B. MECHANICAL FAILURE IN OPERATIONS.  
 ING, AND RIGGER CYLINDERS,  
 TELESCOPE STEERING MOTOR  
 (PM1-10-31.0) AND BOOM TELE-  
 SCOPE CYLINDERS.

31J0382 CONTROL VALVE, CONTROLS DIRECTION A. FAILS OPEN FUNCTION SELECTED WILL NO EFFECT. 3  
 SOLENOID- OF OIL FLOW TO B. MECHANICAL FAILURE; OPERATE UNIMPEDED. DELAY  
 OPERATED, OUTRIGGER CYLIN- RUPTURED OR DAMAGED IN OPERATION.  
 4-WAY; DERS FOR EXTENSION SEALS; DIRT AND/OR  
 OUTRIGGER OR RETRACTION. CONTAMINATION IN  
 SELECTOR VALVE  
 (PM1-43-27.0) C. NA  
 D. VISUAL  
 E. OPERATOR CAN CUT OFF POWER, SAFING THE SYSTEM  
 F. SECONDS  
 G. IMMEDIATE

A. FAILS CLOSED VALVE SECTION INOPERATIVE. NO EFFECT. 3  
 B. MECHANICAL FAILURE DELAY IN OPERATION.

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SAA09FT01-006

System	LINK-BELT 40-TON MOBILE CRANE		Facility or Station Set	MULTIPLE SS/99
Subsystem	MECHANICAL - HYDRAULIC LINK BELT		Page	12 of 20 Date JUNE 1989
Drawing No.	SM7-0-71.0	Sheet No.	Prepared By R. BRINSMADE, LSOC 51-22	
PMN	H72-1394		Program	SPACE SHUTTLE
FIND NO. PART NO.	PART NAME	PART FUNCTION	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY

3A11781 (8 EACH)	CONTROL VALVE SOLENOID-OPERATED (PM1-43-29.0)	A TOTAL OF EIGHT VALVES, FOUR OF WHICH CONTROL THE EXTENSION/RETRACTION OF THE OUTRIGGER CYLINDERS AND FOUR THAT CONTROL THE RAISING/LOWERING OF THE JACK CYLINDERS.	FUNCTION SELECTED WILL OPERATE UNIMPEDED. NO CHANGE IN EXTENSION/RETRACTION SELECTION POSSIBLE. DELAY IN OPERATIONS.	NO EFFECT.	3
45J2032 (4 EACH)	LOCK VALVES (PM1-44-11.0)	MAINTAINS JACK CYLINDERS OF THE OUTRIGGERS PRESSURIZED IN THE EXTENDED POSITION.	A. FAILS CLOSED B. MECHANICAL FAILURE	SECTION OF VALVE INOPERATIVE. DELAY IN OPERATIONS. NO EFFECT.	3
			A. FAILS OPEN B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION IN VALVE	NO EFFECT. JACK CONTROL VALVE PRECLUDES LEAKAGE/BACKFLOW FROM JACK CYLINDER.	3
			A. FAILS CLOSED B. MECHANICAL FAILURE	JACK WILL NOT RAISE OR LOWER. DELAY IN OPERATIONS. NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 13 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.           
 Program SPACE SHUTTLE  
 PMN H72-1394 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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46J1395 (4 EACH)	BEAM CYLINDERS (PM1-45-43.0)	EXTENDS AND RE-TRACTS BEAMS OF OUTRIGGERS.	A. ROD SEAL RUPTURE/TEAR B. EXCESSIVE PRESSURE/CONTAMINATION	OIL LEAK. DELAY IN OPERATIONS.	NO EFFECT.	3
46J1395 (4 EACH) (CONT'D)			A. CYLINDER INTERNAL LEAK B. SEAL WEAR	EXTENSION/RETRACTION OF BEAM CYLINDERS NOT AVAILABLE. DELAY IN OPERATIONS.	NO EFFECT.	3
53J0090 (4 EACH)	JACK CYLINDERS (PM1-46-48.0)	WHEN OUTRIGGER BEAMS ARE EXTENDED, JACK CYLINDERS LIFT CRANE OFF TIRES AND SUPPORT IT.	A. ROD SEAL RUPTURE/TEAR B. EXCESSIVE PRESSURE/CONTAMINATION	OIL LEAK FROM ROD CHAMBER ONLY. JACK CYLINER HAS PRESSURE ALL ON HEAD WHILE UNDER LOAD. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. CYLINDER INTERNAL LEAK B. SEAL WEAR	FLUID LOCK. DELAY IN OPERATIONS.	NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT  
 Drawing No. SM7-0-71.0 Sheet No.           
 PMN H72-1394

Facility or Station Set MULTIPLE SS/99  
 Page 14 of 20 Date JUNE 1989  
 Prepared By R. BRINSMADE, LSOC 51-22

Program SPACE SHUTTLE

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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47J1509 OSCILLATION CONTROL VALVE LOCKS THE REAR AXLE FRAME WHEN HOISTING OPERATIONS ARE PERFORMED OTHER THAN OVER THE FRONT. ANCILLARY COMPONENTS OF VALVE AUTOMATICALLY ACTIVATE VALVE TO SHIFT IT TO ITS "LOCKED" POSITION WHEN THE UPPER FRAME IS ROTATED TO A POSITION OTHER THAN DIRECTLY OVER THE FRONT.

NO EFFECT.

3

FREE FLOW OF OIL BETWEEN OSCILLATION CYLINDERS AND HYDRAULIC SYSTEM RETURN LINES. OSCILLATION SYSTEM WILL NOT OPERATE. DELAY IN OPERATIONS.

A. FAILS CLOSED  
 B. MECHANICAL FAILURE

NO EFFECT.

3

NO OIL FLOW BETWEEN OSCILLATION CYLINDERS AND HYDRAULIC SYSTEM RETURN LINES. AXLE LOCKED IN POSITION. DELAY IN OPERATIONS.

SAA09FT01-006

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 15 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FWN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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47J1509 (CONT'D) OSCILLATION CYLINDERS (2 EACH) IMPROVES MACHINE STABILITY AND FOUR WHEEL CONTACT WITH THE GROUND WHEN TRAVELING OVER ROUGH TERRAIN. ALLOW GRADUAL OSCILLATION OF THE REAR AXLE WHEN THE UPPER FRAME IS OVER THE FRONT OF THE CARRIER.

A. ROD SEAL RUPTURE/TEAR  
 B. EXCESSIVE PRESSURE/CONTAMINATION

OIL LEAK. SUSPENSION CAPABILITIES LOST. CYLINDERS WILL CONSTANTLY BOTTOM OUT. CHASSIS RIDES HARD. DELAY IN OPERATIONS.

NO EFFECT.

3

36J0482 RELIEF VALVE ACTS TO RELIEVE EXCESS PRESSURE ON THE OUTRIGGER, STEERING AND TELESCOPE PUMP CIRCUIT. RELIEF VALVE SETTING AT 2,700 PSI.

A. CYLINDER INTERNAL LEAK  
 B. SEAL WEAR

SUSPENSION CAPABILITIES LOST. CYLINDERS WILL CONSTANTLY BOTTOM OUT. CHASSIS RIDES HARD. DELAY IN OPERATIONS.

NO EFFECT.

3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 16 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.       
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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36J0482  
(CONT'D)

A. FAILS CLOSED  
 B. MECHANICAL FAILURE

OIL FLOW MUST TAKE AVAILABLE  
 OPEN PATH TO RESERVOIR IN  
 ORDER TO RELIEVE PRESSURE.  
 DOUBLE FAILURE REQUIRED TO  
 DAMAGE SYSTEM. DELAY IN  
 OPERATIONS.

3

46J1295

VACUUM/PRES-  
 SURE RELIEF  
 VALVE  
 (PM1-39-36.0)

PREVENTS A VACUUM  
 OR EXCESSIVE PRES-  
 SURE IN HYDRAULIC  
 RESERVOIR. RELIEF  
 VALVE SETTING AT  
 5 PSI.

A. VACUUM VALVE  
 FAILS OPEN  
 B. MECHANICAL FAILURE;  
 DIRT AND/OR CONTAM-  
 INATION

HYDRAULIC RESERVOIR WILL  
 NOT PRESSURIZE. DELAY IN  
 OPERATIONS.

3

46J1295

VACUUM VALVE  
 FAILS CLOSED  
 B. MECHANICAL FAILURE;  
 DIRT AND/OR CONTAM-  
 INATION

OIL FLOW TO PUMPS MAY BE IM-  
 PEDED CAUSING PUMP CAVITA-  
 TION. WHINE FROM PUMPS  
 WOULD INDICATE TO OPERATOR  
 TO SHUT OFF SYSTEM. DOUBLE  
 FAILURE REQUIRED SINCE THERE  
 IS A VENT ON THE RETURN LINE  
 FILTER. DELAY IN OPERATIONS.

3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT Page 17 of 20 Date JUNE 1989  
 Drawing No. SM7-0-71.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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46J1295  
(CONT'D)

A. RELIEF VALVE FAILS OPEN  
 B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION

HYDRAULIC RESERVOIR WILL NOT MAINTAIN PRESSURE. DELAY IN OPERATIONS.

NO EFFECT.

A. RELIEF VALVE FAILS CLOSED  
 B. MECHANICAL FAILURE

HYDRAULIC RESERVOIR BECOMES OVERPRESSURIZED. AIR REGULATOR CUTS OFF AIR SUPPLY. HYDRAULIC OIL DOES NOT DEAERATE. WHINE FROM PUMPS WOULD INDICATE TO OPERATOR TO SHUT OFF SYSTEM. DELAY IN OPERATIONS.

NO EFFECT.

46J0653 CHECK VALVE (PM7-2-43.0)

PREVENTS BACKFLOW FROM STEERING CIRCUIT INTO SWING/TELESCOPE CIRCUIT.

A. FAILS OPEN  
 B. MECHANICAL FAILURE

PRESSURE DIFFERENTIAL BETWEEN STEERING CIRCUIT AND SWING/TELESCOPE CIRCUIT INADEQUATE FOR PROPER OPERATION. SYSTEM INOPERATIVE. DELAY IN OPERATIONS.

NO EFFECT.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System <u>LINK-BELT 40-TON MOBILE CRANE</u>		Facility or Station Set <u>MULTIPLE SS/99</u>	
Subsystem <u>MECHANICAL - HYDRAULIC LINK BELT</u>		Page <u>18</u> of <u>20</u>	Date <u>JUNE 1989</u>
Drawing No. <u>SM7-0-71.0</u> Sheet No. _____		Prepared By <u>R. BRINSMAD, LSOC 51-22</u>	
PMN <u>H72-1394</u>		Program <u>SPACE SHUTTLE</u>	
FIND NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME
PART NO.			FAILURE EFFECT ON SYSTEM PERFORMANCE
			FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY
			CRIT CAT

(CONT'D)

B. MECHANICAL FAILURE  
SWING/TELESCOPE CONTROL CIRCUIT TO BECOME OVERPRESSURIZED. DOUBLE FAILURE REQUIRED SINCE THERE ARE OTHER COMPONENTS ON THE ALTERNATE LINE.

42J1037 PRIORITY FLOW VALVE DIRECTS FLOW AS REQUIRED TO EITHER THE STEERING CONTROL VALVE OR SWING/TELESCOPE CONTROL VALVE. A. FAILS OPEN B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION IN VALVE C. NA D. VISUAL E. OPERATOR CAN CUT OFF POWER TO SAFE SYSTEM F. SECONDS G. IMMEDIATE

FUNCTION SELECTED WILL OPERATE UNIMPEDED. NO CHANGE IN SELECTION POSSIBLE. DELAY IN OPERATIONS.

NO EFFECT.



FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE  
 Subsystem MECHANICAL - HYDRAULIC LINK BELT  
 Drawing No. SM7-0-71.0 Sheet No.           
 PMN H72-1394

Facility or Station Set MULTIPLE SS/99  
 Page 20 of 20 Date JUNE 1989  
 Prepared By R. BRINSMADE, LSOC 51-22

Program SPACE SHUTTLE

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
46J1195 (CONT'D)			A. FAILS CLOSED B. MECHANICAL FAILURE	NO PRESSURE OR FLOW WILL REACH THE SWING/TELESCOPE CONTROL VALVE FROM THE OUTRIGGER, STEERING AND TELESCOPE PUMP. PRIORITY FLOW VALVE WILL CONFIGURE ITS SHUTTLE VALVE TO HAVE THE RETURN OIL REDIRECTED THROUGH THE STEER CONTROL VALVE. DELAY IN OPERATIONS.	NO EFFECT.	3

SAA09FT01-006

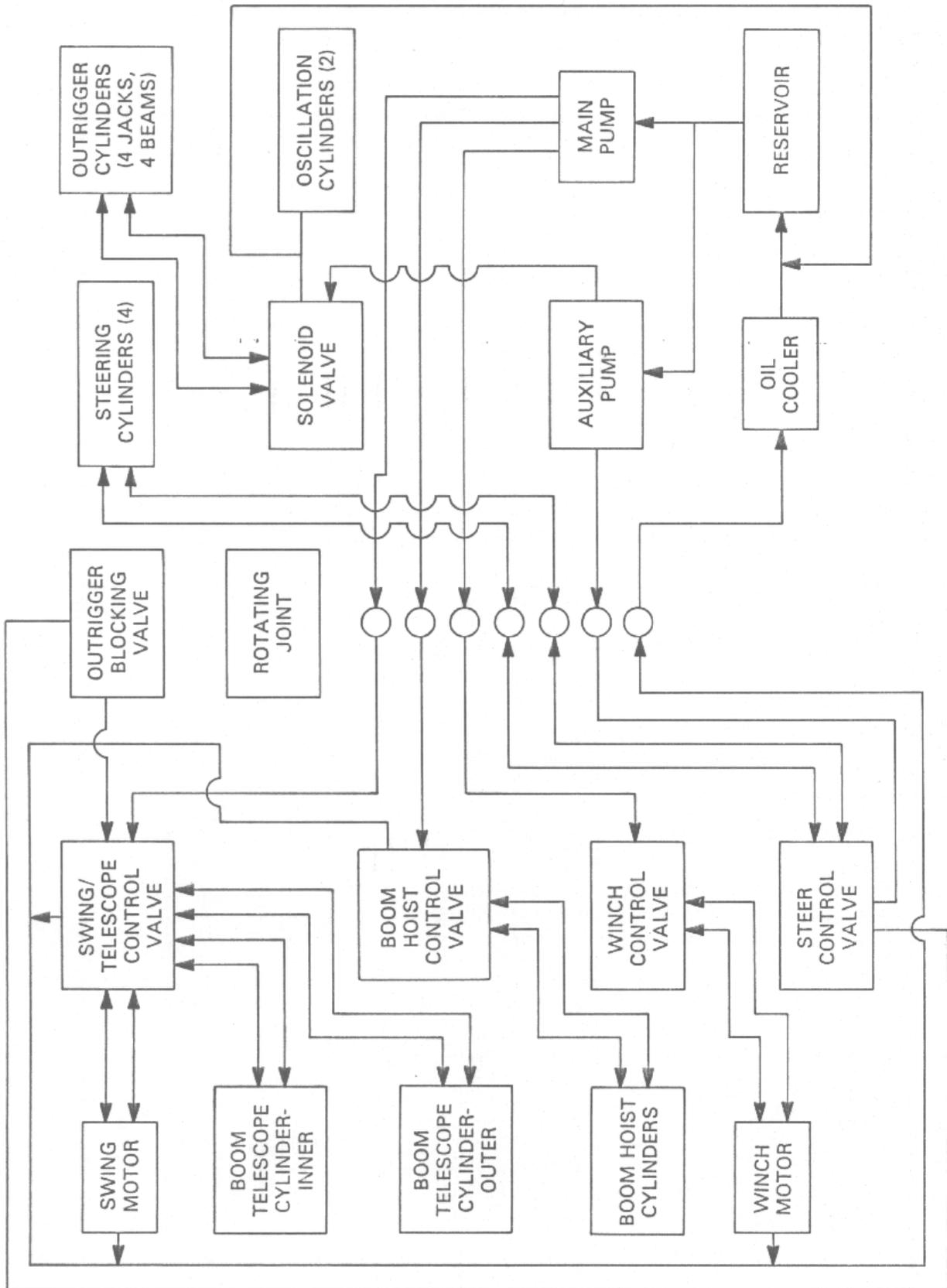


Figure 7. Hydraulic System Block Diagram

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - AIR SYSTEM Page 1 of 8 Date JUNE 1989  
 Drawing No. LINK BELT SM1-27-20.0 Sheet No.       
 PMN      Prepared By R. BRINSMADE, LSOC 51-22  
 Program SPACE SHUTTLE

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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12 CFM AIR COMPRESSOR	SUPPLIES COMPRESSED AIR TO SERVICE BRAKES, PARKING BRAKE, GOVERNOR, THROTTLE TREADLE, HYDRAULIC RESERVOIR AND HOIST SHIFT.		A. FAILS TO SUPPLY COMPRESSED AIR B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION IN COMPRESSOR	FUNCTIONS WILL NOT OPERATE. DELAY IN OPERATIONS.	NO EFFECT.	3
8A2223 SAFETY VALVE	RELIEVES EXCESS PRESSURE FROM AIR RESERVOIR.		A. FAILS OPEN B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION	AIR RESERVOIR LOSES PRESSURE. AIR SYSTEM BECOMES INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
AIR PRESSURE REGULATOR VALVE	REGULATES AMOUNT OF AIR PRESSURIZING THE HYDRAULIC RESERVOIR.		A. FAILS CLOSED B. MECHANICAL FAILURE	AIR RESERVOIR BECOMES OVERPRESSURIZED. GOVERNOR WILL STOP COMPRESSOR FROM FEEDING AIR TO SYSTEM AND VENT IT. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS OPEN B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION	HYDRAULIC RESERVOIR WILL BECOME OVERPRESSURIZED. EXHAUST/RELIEF VALVE ON HYDRAULIC RESERVOIR WILL OPEN AND VENT PRESSURE. DELAY IN OPERATIONS.	NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - AIR SYSTEM Page 2 of 8 Date JUNE 1989  
 Drawing No. LINK BELT SM1-27-20.0 Sheet No. PMN  
 Prepared By R. BRINSMADE, LSOC 51-22

Program SPACE SHUTTLE

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	AIR PRESSURE REGULATOR VALVE (CONT'D)		A. FAILS CLOSED B. MECHANICAL FAILURE	HYDRAULIC RESERVOIR WILL NOT BE PRESSURIZED WITH COMPRESSED AIR. VACUUM/PRESSURE RELIEF ON HYDRAULIC RESERVOIR WILL OPEN TO PREVENT VACUUM. DELAY IN OPERATIONS.	NO EFFECT.	3
	GOVERNOR	CONTROLS PRESSURIZED AIR FROM ENTERING AIR SYSTEM FROM AIR COMPRESSOR	A. FAILS IN SUPPLY "ON" MODE B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION	AIR SYSTEM WILL CONTINUE TO RECEIVE PRESSURIZED AIR. SAFETY VALVE WILL RELIEVE SYSTEM. DELAY IN OPERATIONS.	NO EFFECT.	3
	SOLENOID OPERATED VALVE (PARKING BRAKE)	PROVIDES MOVEMENT CONTROL TO PARKING BRAKE ACTUATOR.	A. FAILS IN SUPPLY "OFF" MODE B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION IN VALVE	AIR SYSTEM WILL NOT BE PRESSURIZED. SYSTEM INOPERATIVE WHEN AIR RESERVOIRS ARE DEPLETED. DELAY IN OPERATIONS.  PARKING BRAKE CANNOT BE RELEASED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION IN VALVE	PARKING BRAKE CANNOT BE APPLIED. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - AIR SYSTEM Page 3 of 8 Date JUNE 1989  
 Drawing No. LINK BELT SM1-27-20.0 Sheet No. PMN  
 Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	QUICK EXHAUST VALVE (PARKING BRAKE)	RELEASES PRESSURIZED AIR FROM PARKING BRAKE ACTUATOR AND VENTS IT TO THE ATMOSPHERE WHEN PARKING BRAKE SOLENOID VALVE CLOSED TO RELEASE BRAKE.	A. FAILS OPEN B. MECHANICAL FAILURE; RUPTURED OR DAMAGED SEALS; DIRT AND/OR CONTAMINATION IN VALVE	FUNCTION SELECTED WILL OPERATE UNIMPEDED. NO CHANGE IN APPLYING/RELEASING BRAKE POSSIBLE. DELAY IN OPERATIONS.	NO EFFECT.	3
53A0742	PARKING BRAKE ACTUATOR (PM1-30-17.0)	MOVES PARKING BRAKE CALIPER TO APPLY OR RELEASE THEM.	A. FAILS EXTENDED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION IN ACTUATOR	PARKING BRAKE WILL NOT BE RELEASED. DELAY IN OPERATIONS.	NO EFFECT.	3
	THROTTLE TREADLE	PROVIDES MOVEMENT CONTROL TO THROTTLE CONTROL CYLINDER.	A. FAILS RETRACTED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION IN ACTUATOR	PARKING BRAKE WILL NOT BE APPLIED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION	THROTTLE WILL NOT OPERATE. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - AIR SYSTEM Page 4 of 8 Date JUNE 1989  
 Drawing No. LINK BELT SM1-27-20.0 Sheet No.       
 PMN      Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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<p>THROTTLE TREADLE (CONT'D)</p>	<p>A. FAILS OPEN B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION</p>	<p>THROTTLE CONTROL CYLINDER ON ENGINE CANNOT BE CONTROLLED. GOVERNOR WILL LIMIT ENGINE SPEED. DELAY IN OPERATIONS.</p>	<p>NO EFFECT.</p>	<p>3</p>
<p>THROTTLE LOCK VALVE SOLENOID OPERATED</p>	<p>A. FAILS OPEN B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION</p>	<p>THROTTLE WILL OPERATE UNIMPEDED. THROTTLE CONTROL CYLINDER CANNOT BE BLOCKED OUT OF CIRCUIT. DELAY IN OPERATIONS.</p>	<p>NO EFFECT.</p>	<p>3</p>
<p>THROTTLE CONTROL CYLINDER</p>	<p>A. FAILS CLOSED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION</p>	<p>VALVE INOPERATIVE. DELAY IN OPERATIONS.</p>	<p>NO EFFECT.</p>	<p>3</p>
<p>THROTTLE CONTROL CYLINDER THROTTLE LEVER</p>	<p>A. FAILS EXTENDED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION</p>	<p>THROTTLE OPERATES UNIMPEDED. DELAY IN OPERATIONS.</p>	<p>NO EFFECT.</p>	<p>3</p>

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE  
 Subsystem MECHANICAL - AIR SYSTEM  
 Drawing No. LINK BELT SM1-27-20.0 Sheet No. PMN  
 Facility or Station Set MULTIPLE SS/99  
 Page 5 of 8 Date JUNE 1989  
 Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	THROTTLE CON- TROL CYLINDER (CONT'D)		A. FAILS RETRACTED B. MECHANICAL FAILURE; DIRT AND/OR CONTAM- INATION IN ACTUATOR	THROTTLE OPERATES UNIMPEDED. DELAY IN OPERATIONS.	NO EFFECT.	3
46J1435	BRAKE TREADLE (PM7-26-25.0)	PROVIDES MOVEMENT CONTROL TO AIR/ HYDRAULIC PRESSURE CONVERTORS - BRAKES	A. FAILS OPEN B. MECHANICAL FAILURE; DIRT AND/OR CONTAM- INATION C. NA D. VISUAL E. OPERATOR CAN SLOW DOWN AND USE PARK- ING BRAKE F. SECONDS G. IMMEDIATE	COMPRESSED AIR WILL LEAVE LINE CONTROLLING RELAY VALVE FOR AIR/HYDRAULIC PRESSURE CONVERTORS - BRAKES. SER- VICE BRAKES WILL NOT OPER- ATE. DELAY IN OPERATIONS.	NO EFFECT.	3
	STOP LIGHT SWITCH	ALLOWS CURRENT FLOW TO STOP (BRAKE) LIGHTS.	A. FAILS CLOSED B. MECHANICAL FAILURE; DIRT AND/OR CONTAM- INATION	SERVICE BRAKES WILL BE CON- TINUALLY APPLIED. DELAY IN OPERATIONS.	NO EFFECT.	3
	STOP LIGHT SWITCH	ALLOWS CURRENT FLOW TO STOP (BRAKE) LIGHTS.	A. FAILS OPEN B. MECHANICAL FAILURE; DIRT AND/OR CONTAM- INATION	STOP (BRAKE) LIGHTS WILL NOT LIGHT UP. DELAY IN OPERA- TIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SAA09FT01-006

System Subsystem	LINK-BELT 40-TON MOBILE CRANE MECHANICAL - AIR SYSTEM	Program	SPACE SHUTTLE	Facility or Station Set	MULTIPLE SS/99	
Drawing No.	LINK BELT SM1-27-20.0 Sheet No.			Page	6 of 8 Date JUNE 1989	
PHN		Prepared By R. BRINSMADE, LSOC 51-22				
FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT

STOP LIGHT  
SWITCH  
(CONT'D)

A. FAILS CLOSED  
B. MECHANICAL FAILURE;  
DIRT AND/OR CONTAM-  
INATION

3

LOW AIR  
PRESSURE  
SWITCH

INDICATES AIR  
PRESSURE AVAIL-  
ABLE FOR BRAKE  
APPLICATION.

A. FAILS CLOSED  
B. MECHANICAL FAILURE;  
DIRT AND/OR CONTAM-  
INATION

CONSTANT INDICATION OF LOW  
AIR PRESSURE. DELAY IN  
OPERATIONS.

3

LOW AIR PRESSURE NOT  
INDICATED. DELAY IN  
OPERATIONS.

A. FAILS OPEN  
B. MECHANICAL FAILURE;  
DIRT AND/OR CONTAM-  
INATION

NO EFFECT.

3

- C. NA
- D. OPERATOR WILL SENSE  
LOW AIR PRESSURE  
WHEN BRAKES APPLIED
- E. OPERATOR CAN CUT OFF  
POWER TO SAFE SYSTEM
- F. VARIABLE
- G. IMMEDIATE

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

SAA09FT01-006

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - AIR SYSTEM Page 7 of 8 Date JUNE 1989  
 Drawing No. LINK BELT SM1-27-20.0 Sheet No. PMN  
 Program SPACE SHUTTLE  
 Prepared By R. BRINSMAD, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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53A0616 RELAY VALVE (PM1-27-181.0) CONTROLS COM-PRESSED AIR MOVEMENT TO AND FROM THE AIR/HYDRAULIC PRESSURE CONVERTORS - BRAKES.

A. FAILS OPEN  
 B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION  
 C. NA  
 D. VISUAL  
 E. OPERATOR CAN SET PARKING BRAKE AND CUT OFF POWER TO SAFE SYSTEM  
 F. VARIABLE  
 G. IMMEDIATE

AIR/HYDRAULIC PRESSURE CONVERTORS - BRAKES WILL NOT OPERATE. DELAY IN OPERATIONS.

NO EFFECT.

46A1008 AIR/HYDRAULIC PRESSURE CONVERTORS - BRAKES (PM1-27-139.0) 4 EACH

A. FAILS CLOSED  
 B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION

SERVICE BRAKES WILL CON- STANTLY BE APPLIED. OPERATOR CAN SET PARKING BRAKE AND CUT OFF POWER TO SAFE SYSTEM. DELAY IN OPERATIONS.

NO EFFECT.

46A1008 AIR/HYDRAULIC PRESSURE CONVERTORS - BRAKES (PM1-27-139.0) 4 EACH

A. FAILS OPEN  
 B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION

AFFECTED SERVICE BRAKE WILL NOT APPLY. OPERATOR CAN SET PARKING BRAKES AND CUT OFF POWER TO SAFE SYSTEM. DELAY IN OPERATIONS.

NO EFFECT.

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - AIR SYSTEM Page 8 of 8 Date JUNE 1989  
 Drawing No. LINK BELT SMI-27-20.0 Sheet No. PMN  
 Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
46A1008 (CONT'D)			A. FAILS CLOSED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION	AFFECTED SERVICE BRAKE WILL BE CONSTANTLY APPLIED. OPERATOR CAN CUT OFF POWER TO SAFE SYSTEM. DELAY IN OPERATIONS.	NO EFFECT.	3
6310097	2-SPEED HOIST SHIFT SOLENOID VALVE (PM7-26-21.0)	CONTROLS POSITION OF ACTUATOR FOR SHIFTING HOIST SPEED.	A. FAILS OPEN B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION	HOIST WILL CONSTANTLY OPERATE IN LOW SPEED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION	HOIST WILL CONSTANTLY OPERATE IN HIGH SPEED. DELAY IN OPERATIONS.	NO EFFECT.	3
	HOIST 2-SPEED SHIFT ACTUATOR	CHANGES POSITION OF VALVE ON HOIST HYDRAULIC MOTOR FOR SELECTION OF HIGH OR LOW SPEED.	A. FAILS RETRACTED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION	HOIST WILL CONSTANTLY OPERATE IN LOW SPEED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS EXTENDED B. MECHANICAL FAILURE; DIRT AND/OR CONTAMINATION	HOIST WILL CONSTANTLY OPERATE IN HIGH SPEED. DELAY IN OPERATIONS.	NO EFFECT.	3

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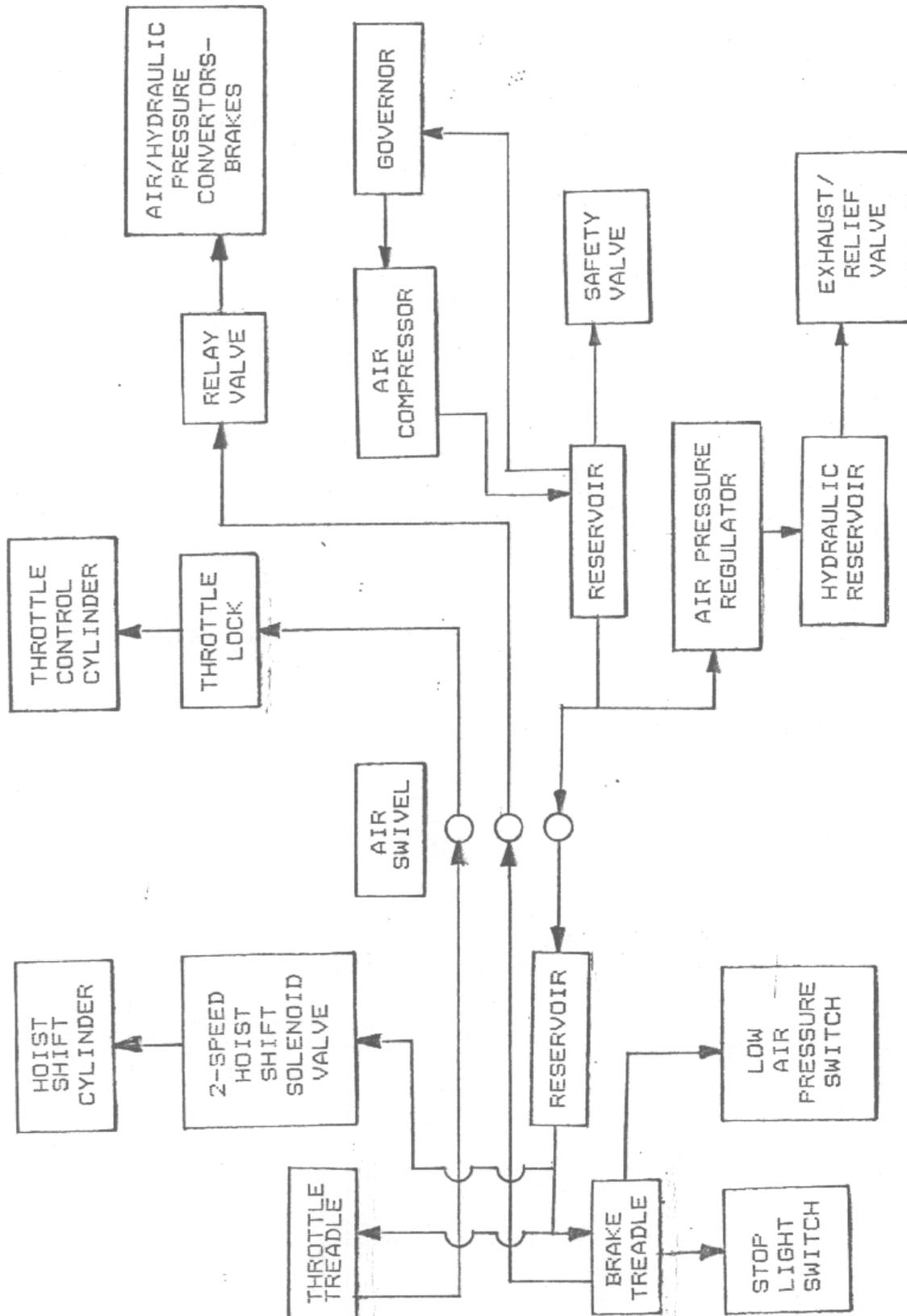


Figure 8. Air System Block Diagram

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem MECHANICAL - POWER AND SUPPORT Page 1 of 1 Date JUNE 1989  
 Drawing No. LINK BELT SM1-27-20.0 Sheet No.       
 PMN Program SPACE SHUTTLE  
 Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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ENGINE ASSEMBLY PROVIDES ALL OPERATING POWER TO THE CRANE SYSTEMS. A. INOPERATIVE ALL CRANE SYSTEMS INOPERATIVE (EXCEPT FOR ELECTRICAL). DELAY IN OPERATIONS. NO EFFECT. 3

46A0941 TORQUE CONVERTOR ASSEMBLY (PM1-18-54.0) TRANSMITS POWER FROM ENGINE TO THE TRANSMISSION AND DRIVES HYDRAULIC PUMPS. A. SLIPPING CRANE LOCOMOTION AND HOISTING SYSTEMS INOPERABLE. DELAY IN OPERATIONS. NO EFFECT. 3

53B0021 TURNTABLE BEARING SUPPORTS AND ALLOWS ROTATION OF THE UPPER REVOLVING FRAME ABOUT A SINGLE AXIS ON THE CHASSIS. A. TURNTABLE WILL NOT ROTATE B. BEARING SEIZES (STRUCTURAL FAILURE) UPPER REVOLVING FRAME WILL NOT ROTATE. DELAY IN OPERATIONS. NO EFFECT. 3

## 2.6 ELECTRICAL FMEA WORKSHEETS AND BLOCK DIAGRAMS

The electrical components of this system were identified from the documents and diagrams referenced in the Documentation List and are analyzed on the following FMEA worksheets (form 21-232a).

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem ELECTRICAL Program SPACE SHUTTLE Page 1 of 19 Date JUNE 1989  
 Drawing No. SKETCH SM6-47-36.0 Sheet No. H72-1394  
 PMN Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	BATTERY	STORES ELECTRICAL ENERGY TO POWER SYSTEM.	A. FAILS SHORT B. DEFECTIVE PLATES	BATTERY WILL NOT OPERATE TO POWER SYSTEM. CRANE INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
	STARTER SOLENOID	WHEN ACTIVATED, IT ENGAGES STARTER MOTOR TO TURN OVER ENGINE.	A. FAILS OPEN B. STRUCTURAL FAILURE	BATTERY WILL NOT OPERATE TO POWER SYSTEM. CRANE INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
	STARTER RELAY	PROVIDES CIRCUITRY FOR ENERGIZING THE CRANE ELECTRICAL SYSTEM.	A. FAILS ACTIVATED B. SHORT OR WELDED CONTACTS	ENGINE STARTER MOTOR REMAINS ENGAGED. POSSIBLE DAMAGE TO STARTER MOTOR. DELAY IN OPERATIONS.	NO EFFECT.	3
	STARTER RELAY	PROVIDES CIRCUITRY FOR ENERGIZING THE CRANE ELECTRICAL SYSTEM.	A. FAILS DEACTIVATED B. VIBRATION	ENGINE STARTER MOTOR FAILS TO ENGAGE. ENGINE WILL NOT TURN OVER. DELAY IN OPERATIONS.	NO EFFECT.	3
	STARTER RELAY	PROVIDES CIRCUITRY FOR ENERGIZING THE CRANE ELECTRICAL SYSTEM.	A. FAILS OPEN B. VIBRATION	CRANE ELECTRICAL SYSTEM FAILS TO ENERGIZE. CRANE WILL NOT OPERATE. DELAY IN OPERATIONS.	NO EFFECT.	3
	STARTER RELAY	PROVIDES CIRCUITRY FOR ENERGIZING THE CRANE ELECTRICAL SYSTEM.	A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	CRANE ELECTRICAL SYSTEM IS CONSTANTLY ENERGIZED. BATTERY WAY DISCHARGE. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
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 PMN Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	ALTERNATOR	PRODUCES ALTERNATING CURRENT TO POWER SYSTEM.	A. INOPERATIVE B. DEFECTIVE WINDING	FAILURE EFFECT ON SYSTEM PERFORMANCE ALTERNATOR WILL NOT OPERATE TO PRODUCE POWER FOR SYSTEM. CRANE INOPERATIVE. DELAY IN OPERATIONS.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY NO EFFECT.	3
	ENGINE SHUT-DOWN SOLENOID	SHORTS IGNITION CIRCUIT TO GROUND IN ORDER TO STOP ENGINE.	A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	FAILURE EFFECT ON SYSTEM PERFORMANCE ENGINE WILL CEASE OPERATING AND CANNOT BE RESTARTED. DELAY IN OPERATIONS.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY NO EFFECT.	3
	CIRCUIT BREAKER (60A)	PROVIDES OVER-CURRENT PROTECTION FOR ENGINE RUN CIRCUIT AND UPPER CHASSIS CIRCUIT.	A. FAILS OPEN B. VIBRATION	FAILURE EFFECT ON SYSTEM PERFORMANCE ENGINE OPERABLE, THE ENGINE WILL NOT STOP WHEN THE IGNITION SWITCH IS TURNED TO THE OFF POSITION. DELAY IN OPERATIONS.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY NO EFFECT.	3
	CIRCUIT BREAKER (15A)	PROVIDES OVER-CURRENT PROTECTION FOR ENGINE RUN CIRCUIT.	A. FAILS TO TRIP B. CONTACTS FUSED TOGETHER	FAILURE EFFECT ON SYSTEM PERFORMANCE ELECTRICAL SYSTEM BECOMES INOPERATIVE. DELAY IN OPERATIONS.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY NO EFFECT.	3
	CIRCUIT BREAKER (15A)	PROVIDES OVER-CURRENT PROTECTION FOR ENGINE RUN CIRCUIT.	A. FAILS TO TRIP B. CONTACTS FUSED TOGETHER	FAILURE EFFECT ON SYSTEM PERFORMANCE OVERCURRENT PROTECTION LOST. DOUBLE FAILURE REQUIRED. DELAY IN OPERATIONS.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY NO EFFECT.	3
	CIRCUIT BREAKER (15A)	PROVIDES OVER-CURRENT PROTECTION FOR ENGINE RUN CIRCUIT.	A. PREMATURE TRIP B. EXCESSIVE HEAT	FAILURE EFFECT ON SYSTEM PERFORMANCE RUN CIRCUIT OF ELECTRICAL SYSTEM BECOMES INOPERATIVE. DELAY IN OPERATIONS.	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
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 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

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FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	CIRCUIT BREAKER (15A) (CONT'D)		A. FAILS TO TRIP B. CONTACTS FUSED TOGETHER	OVERCURRENT PROTECTION FOR RUN CIRCUIT LOST. DOUBLE FAILURE REQUIRED. DELAY IN OPERATIONS.	NO EFFECT.	3
	RUN RELAY	ENABLES HOUR METER, STARTER RELAY, HORN RELAY AND OUTRIGGER RELAY.	A. FAILS OPEN B. VIBRATION	RUN CIRCUIT OF ELECTRICAL SYSTEM BECOMES INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	CIRCUIT WILL REMAIN CLOSED. SYSTEM CAN BE DE-ENERGIZED WITH IGNITION SWITCH. DELAY IN OPERATIONS.	NO EFFECT.	3
	ETHER START SYSTEM	ALLOWS FOR COLD WEATHER ENGINE STARTS.	A. FAILS ACTIVATED B. FAULTY CONTACTS	ETHER WILL BE EXHAUSTED, PREVENTING ADDITIONAL COLD WEATHER ENGINE STARTS. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS DEACTIVATED B. FAULTY CONTACTS	ETHER NOT AVAILABLE TO ENGINE. COLD WEATHER ENGINE STARTS PREVENTED. DELAY IN OPERATIONS.	NO EFFECT.	3
	NEUTRAL START SWITCH	ENABLES ALL CONTROL, OPERATIONAL AND INDICATOR CIRCUITS.	A. FAILS OPEN B. VIBRATION	CONTROL, OPERATIONAL, AND INDICATOR CIRCUITS BECOME IN OPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
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 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	NEUTRAL START SWITCH (CONT'D)		A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	CIRCUITS WILL REMAIN CLOSED. SYSTEM CAN BE DE-ENERGIZED WITH IGNITION SWITCH. DELAY IN OPERATIONS.	NO EFFECT.	3
	UPPER MAIN RELAY	ENABLES ALL CONTROL, OPERATIONAL, AND INDICATOR CIRCUITS.	A. FAILS OPEN B. VIBRATION	CONTROL, OPERATIONAL, AND INDICATOR CIRCUITS BECOME INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	CIRCUITS WILL REMAIN CLOSED. SYSTEM CAN BE DE-ENERGIZED WITH IGNITION SWITCH. DELAY IN OPERATIONS.	NO EFFECT.	3
	HOUR METER	INDICATES AMOUNT OF ENGINE RUNNING TIME.	A. ERRONEOUS INDICATION B. VIBRATION	ENGINE RUNNING TIME WILL NOT BE PROPERLY RECORDED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS OPEN B. VIBRATION	ENGINE RUNNING TIME WILL NOT BE RECORDED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS SHORT B. VIBRATION	ENGINE RUNNING TIME WILL NOT BE RECORDED. DELAY IN OPERATIONS.	NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
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 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	CIRCUIT BREAKER "A"	PROVIDES OVER- CURRENT PROTECTION FOR BRAKE LIGHT SWITCH AND TURN SIGNALS.	A. PREMATURE TRIP B. VIBRATION	BRAKE LIGHT SWITCH AND TURN SIGNALS BECOME INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
	CIRCUIT BREAKER "B"	PROVIDES OVER- CURRENT PROTEC- TION FOR VEHICLE LIGHTS, 2-SPEED HOIST SOLENOID VALVE, 4-WHEEL DRIVE SWITCH AND THROTTLE LOCK.	A. FAILS TO TRIP B. CONTACTS FUSED TOGETHER	OVERCURRENT PROTECTION LOST. DOUBLE FAILURE REQUIRED. DELAY IN OPERATIONS.	NO EFFECT.	3
	CIRCUIT BREAKER "B"	PROVIDES OVER- CURRENT PROTEC- TION FOR VEHICLE LIGHTS, 2-SPEED HOIST SOLENOID VALVE, 4-WHEEL DRIVE SWITCH AND THROTTLE LOCK.	A. PREMATURE TRIP B. VIBRATION	VEHICLE LIGHTS, 2-SPEED HOIST SOLENOID VALVE, 4-WHEEL DRIVE SWITCH, AND THROTTLE LOCK BECOME INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS TO TRIP B. CONTACTS FUSED TOGETHER	OVERCURRENT PROTECTION LOST. DOUBLE FAILURE REQUIRED. DELAY IN OPERATIONS.	NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem ELECTRICAL Page 6 of 19 Date JUNE 1989  
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 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

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FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	CIRCUIT BREAKER "C"	PROVIDES OVER-CURRENT PROTECTION FOR TRANSMISSION SHIFT SELECTOR, TRANSMISSION SHIFT VALVES 1 THROUGH 5, EMERGENCY FLASHER, TRAVEL ALARM, AND BACK-UP TRAVEL ALARM.	A. PREMATURE TRIP B. VIBRATION	TRANSMISSION SHIFT SELECTOR, TRANSMISSION SHIFT VALVES 1 THROUGH 5, EMERGENCY FLASHER, TRAVEL ALARM, AND BACK-UP TRAVEL ALARM BECOME INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
	CIRCUIT BREAKER "D"	PROVIDES OVER-CURRENT PROTECTION FOR LOW AIR PRESSURE LIGHT, VEHICLE GAGES, LOW AIR PRESSURE SWITCH, AND REAR STEER INDICATOR.	A. FAILS TO TRIP B. CONTACTS FUSED TOGETHER	OVERCURRENT PROTECTION LOST. DOUBLE FAILURE REQUIRED. DELAY IN OPERATIONS.	NO EFFECT.	3
	CIRCUIT BREAKER "E"	PROVIDES OVER-CURRENT PROTECTION FOR COMBINATION STEERING.	A. PREMATURE TRIP B. VIBRATION	COMBINATION STEERING BECOMES INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
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 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	CIRCUIT BREAKER "E" (CONT'D)		A. FAILS TO TRIP B. CONTACTS FUSED TOGETHER	OVERCURRENT PROTECTION LOST. DOUBLE FAILURE REQUIRED. DELAY IN OPERATIONS.	NO EFFECT.	3
	CIRCUIT BREAKER "F"	PROVIDES OVER-CURRENT PROTECTION FOR OUTRIGGER CONTROL SWITCHES AND VALVE SOLENOIDS.	A. PREMATURE TRI B. VIBRATION	OUTRIGGER CONTROL SWITCHES AND VALVE SOLENOIDS BECOME INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS TO TRIP B. CONTACTS FUSED TOGETHER	OVERCURRENT PROTECTION LOST. DOUBLE FAILURE REQUIRED. DELAY IN OPERATIONS.	NO EFFECT.	3
	IGNITION SWITCH	CONNECTS POWER TO SYSTEM CONTROLS. ENABLES UPPER MAIN RELAY, OUTRIGGER RELAY, AND TRANSMISSION SHIFT SELECTOR.	A. FAILS OPEN B. FAULTY CONTACTS	UPPER MAIN RELAY, OUTRIGGER RELAY, AND TRANSMISSION SHIFT SELECTOR WILL NOT BE ENABLED. SYSTEM INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	STARTER MOTOR WILL BE CONSTANTLY ENGAGED IN A "START UP" MODE. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
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 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	HORN	MAKES AN AUDIBLE WARNING SIGNAL WHEN USED.	A. FAILS OPEN B. FAULTY CONTACTS	HORN WILL NOT SOUND. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	HORN WILL SOUND CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3
	BRAKE LIGHT SWITCH	CONNECTS POWER TO BRAKE LIGHTS.	A. FAILS OPEN B. FAULTY CONTACTS	BRAKE LIGHTS WILL NOT BE ILLUMINATED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	BRAKE LIGHTS WILL BE ON CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3
	TURN SIGNAL SWITCH	CONNECTS POWER TO TURN SIGNAL LIGHTS.	A. FAILS OPEN B. FAULTY CONTACTS	TURN SIGNAL WILL NOT BE ILLUMINATED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	TURN SIGNAL WILL BE ON CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
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 Drawing No. SKETCH SM6-47-36.0 Sheet No.           
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 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	VEHICLE LIGHT SWITCH	CONNECTS POWER TO VEHICLE LIGHTS.	A. FAILS OPEN B. FAULTY CONTACTS	VEHICLE LIGHTS WILL NOT BE ILLUMINATED. DELAY IN OPERATIONS.	NO EFFECT.	3
	HORN RELAY	ENABLES HORN CIRCUIT.	A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	VEHICLE LIGHTS WILL BE ON CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3
	TRANSMISSION SHIFT SELECTOR	SELECTS DRIVE SPEED AND DIRECTION BY ENABLING TRANSMISSION SHIFT VALVES.	A. FAILS OPEN B. VIBRATION	HORN CIRCUIT BECOMES INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	CIRCUIT WILL REMAIN CLOSED. SYSTEM CAN BE DE-ENERGIZED WITH IGNITION SWITCH. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS OPEN B. FAULTY CONTACTS	SELECTED DRIVE SPEED AND DIRECTION NOT AVAILABLE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	DRIVE SPEED AND DIRECTION CANNOT BE CHANGED. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	LOW AIR PRESSURE LIGHT	SAFETY DEVICE. WARNS OPERATOR OF LOW AIR PRESSURE WHEN LIT.	A. FAILS OPEN B. VIBRATION	VISUAL ALARM TO OPERATOR IS LOST. DURING HOISTING OPERATIONS, COMPRESSED AIR IS REQUIRED TO CHANGE HOISTING SPEEDS. OPERATOR WILL BECOME AWARE OF LOW AIR PRESSURE WHEN HOIST DOES NOT CHANGE SPEED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS SHORT B. VIBRATION	VISUAL ALARM TO OPERATOR IS LOST. DURING HOISTING OPERATIONS, COMPRESSED AIR IS REQUIRED TO CHANGE HOISTING SPEEDS. OPERATOR WILL BECOME AWARE OF LOW AIR PRESSURE WHEN HOIST DOES NOT CHANGE SPEED. DELAY IN OPERATIONS.	NO EFFECT.	3



FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem ELECTRICAL Page 12 of 19 Date JUNE 1989  
 Drawing No. SKETCH SM6-47-36.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	OUTRIGGER RELAY	ENABLES OUTRIGGER CONTROL CIRCUIT.	A. FAILS OPEN B. VIBRATION	OUTRIGGER CONTROL CIRCUIT BECOMES INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	CIRCUIT WILL REMAIN CLOSED. SYSTEM CAN BE DE-ENERGIZED WITH IGNITION SWITCH. DELAY IN OPERATIONS.	NO EFFECT.	3
	TRANSMISSION SHIFT VALVE SOLENOIDS (5 EACH)	CAUSE VALVES TO CHANGE POSITION, RESULTING IN CONFIGURATION CHANGE TO TRANSMISSION'S TORQUE TRANSFER COMPONENTS.	A. FAILS ACTIVATED B. SHORT OR WELDED CONTACTS	TRANSMISSION REMAINS IN CONFIGURATION SELECTED. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS DEACTIVATED B. VIBRATION	TRANSMISSION REMAINS IN CONFIGURATION SELECTED. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem ELECTRICAL Page 13 of 19 Date JUNE 1989  
 Drawing No. SKETCH SM6-47-36.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	LOW AIR PRESSURE SWITCH	CONNECTS POWER TO LOW AIR PRESSURE LIGHT.	A. FAILS OPEN B. FAULTY CONTACTS	LOW AIR PRESSURE LIGHT WILL NOT LIGHT UP. VISUAL ALARM TO OPERATOR IS LOST. DURING HOISTING OPERATIONS, COMPRESSED AIR IS REQUIRED TO CHANGE HOISTING SPEEDS. OPERATOR WILL BECOME AWARE OF LOW AIR PRESSURE WHEN HOIST DOES NOT CHANGE SPEED. DELAY IN OPERATIONS.	NO EFFECT.	3
	REAR STEER INDICATOR	INDICATES WHEN THE REAR WHEELS ARE NOT IN LINE WITH THE CARRIER.	A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	LOW AIR PRESSURE LIGHT WILL BE CONTINUOUSLY LIT. DELAY IN OPERATIONS.	NO EFFECT.	3
	REAR STEER INDICATOR	INDICATES WHEN THE REAR WHEELS ARE NOT IN LINE WITH THE CARRIER.	A. FAILS OPEN B. FAULTY CONTACTS	REAR WHEELS NOT IN LINE WITH THE CARRIER IS OF CONCERN WHEN CRANE IS BEING STEERED WITH FRONT WHEELS FOR TRAVEL. OPERATING PROCEDURES WHEN FLIGHT HARDWARE IS BEING CARRIED REQUIRE SLOW TRAVEL SPEEDS. THE REAR WHEEL MISALIGNMENT WOULD NOT BE HAZARDOUS AND WOULD BE DETECTABLE WHEN TRAVELING. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem ELECTRICAL Page 14 of 19 Date JUNE 1989  
 Drawing No. SKETCH SM6-47-36.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	REAR STEER INDICATOR (CONT'D)		A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	INDICATOR WILL BE ON CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3
	BEAM/JACK OUTTRIGGER CONTROL SWITCH (4 EACH)	USED TO SELECT EITHER THE BEAM OR JACK OF A PARTICULAR OUT-RIGGER THAT WILL BE EXTENDED OR RETRACTED.	A. FAILS OPEN B. FAULTY CONTACTS	SELECTION FUNCTION OF EITHER A BEAM OR A JACK ON A PARTICULAR OUTTRIGGER WILL NOT BE OPERABLE. DELAY IN OPERATIONS.	NO EFFECT.	3
	4-WHEEL DRIVE SWITCH	USED TO SELECT EITHER 2-WHEEL (REAR AXLE ONLY) OR FOUR WHEEL (BOTH FRONT AND REAR AXLE) DRIVE FOR THE CARRIER WHEN TRAVELLING.	A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	ONE OF THE TWO SELECTIONS (BEAM OR JACK) WILL BE ENGAGED. THE OTHER SELECTION CANNOT BE MADE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS OPEN B. FAULTY CONTACTS	SELECTION FUNCTION OF EITHER 2-WHEEL OR 4-WHEEL DRIVE WILL NOT BE OPERABLE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	ONE OF THE TWO SELECTIONS (2-WHEEL OR 4-WHEEL DRIVE) WILL BE ENGAGED. THE OTHER SELECTION CANNOT BE MADE. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem ELECTRICAL Page 15 of 19 Date JUNE 1989  
 Drawing No. SKETCH SM6-47-36.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	THROTTLE LOCK SOLENOID	BLOCKS OUT THROTTLE CONTROL CYLINDER FROM THROTTLE TREADLE AND AIR SYSTEM.	A. FAILS ACTIVATED B. SHORT OR WELDED CONTACTS	VALVE BECOMES INOPERATIVE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS DEACTIVATED B. VIBRATION	THROTTLE WILL OPERATE UNIMPEDED. THROTTLE CONTROL CYLINDER CANNOT BE BLOCKED OUT OF CIRCUIT. DELAY IN OPERATIONS.	NO EFFECT.	3
	TRAVEL ALARM SWITCH	CONNECTS POWER TO BACK UP TRAVEL ALARM.	A. FAILS OPEN B. FAULTY CONTACTS	BACK UP TRAVEL ALARM WILL NOT OPERATE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	BACK UP TRAVEL ALARM WILL OPERATE CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3
	BACK UP TRAVEL ALARM	GIVES AN AUDIBLE SIGNAL WHEN THE CRANE MOVES IN REVERSE.	A. FAILS OPEN B. FAULTY CONTACTS	BACK UP TRAVEL ALARM WILL NOT OPERATE. DELAY IN OPERATIONS.	NO EFFECT.	3
			A. FAILS CLOSED B. SHORT OR WELDED CONTACTS	BACK UP TRAVEL ALARM WILL OPERATE CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem ELECTRICAL Page 16 of 19 Date JUNE 1989  
 Drawing No. SKETCH SM6-47-36.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	EMERGENCY FLASHER	PROVIDES THE CAPABILITY FOR THE VEHICLE PARKING LIGHTS TO FLASH ON AND OFF CONTINUOUSLY WHEN ENGAGED.	A. FAILS ACTIVATED B. SHORT OR WELDED CONTACTS  A. FAILS DEACTIVATED B. VIBRATION	EMERGENCY FLASHER WILL OPERATE CONTINUOUSLY. DELAY IN OPERATIONS.  EMERGENCY FLASHER WILL NOT OPERATE. DELAY IN OPERATIONS.	NO EFFECT.  NO EFFECT.	3  3

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FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility or Station Set MULTIPLE SS/99  
 Subsystem ELECTRICAL Page 17 of 19 Date JUNE 1989  
 Drawing No. SKETCH SM6-47-36.0 Sheet No.           
 PMN H72-1394 Program SPACE SHUTTLE  
 Prepared By R. B. BRINSMADE, LSOC 51-22

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	BOOM LENGTH/ BOOM ANGLE INDICATOR	DISPLAYS EITHER BOOM ANGLE OR BOOM LENGTH AS REQUESTED. DIS- PLAYS AND SOUNDS AN ALARM (HORN) WHEN THE MINIMUM OR MAXIMUM PARA- METERS ARE AT- TAINED.	A. DOES NOT DISPLAY EITHER BOOM ANGLE OR BOOM LENGTH B. FAULTY COMPONENTS	OPERATOR MUST RELY ON MECH- ANICAL INDICATOR FOR BOOM ANGLE AND VISUALLY GAUGE BOOM LENGTH.	NO EFFECT.	3
	ALARM SWITCH FOR ANTI-TWO BLOCK SYSTEM	ACTIVATES WARNING DEVICES (HORN & LIGHT) OF ANTI- TWO BLOCK SYSTEM.	A. ERRONEOUS DISPLAY OF EITHER BOOM ANGLE OR BOOM LENGTH B. FAULTY COMPONENTS	OPERATOR MUST RELY ON MECH- ANICAL INDICATOR FOR BOOM ANGLE AND VISUALLY GAUGE BOOM LENGTH.	NO EFFECT.	3
	ALARM SWITCH FOR ANTI-TWO BLOCK SYSTEM	ACTIVATES WARNING DEVICES (HORN & LIGHT) OF ANTI- TWO BLOCK SYSTEM.	A. FAILS CLOSED B. WELDED CONTACTS	WARNING DEVICES WILL BE SIGNALLING CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System Subsystem	LINK-BELT 40-TON MOBILE CRANE ELECTRICAL		Program	SPACE SHUTTLE		Facility or Station Set	MULTIPLE SS/99	
Drawing No.	SKETCH SM6-47-36.0		Page	18	of	19	Date	JUNE 1989
PMN	H72-1394		Prepared By	R. B. BRINSMADE, LSOC 51-22				

FIND NO. PART NO.	PART NAME	PART FUNCTION	A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON SYSTEM PERFORMANCE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
	ALARM SWITCH FOR ANTI-TWO BLOCK SYSTEM (CONT'D)		A. FAILS OPEN B. FAULTY CONTACTS C. NA D. AUDIBLE/VISUAL E. THE OPERATOR WILL STOP HOISTING BY RELEASING THE CONTROL VALVE LEVER F. SECONDS G. IMMEDIATE	WARNING DEVICES WILL NOT SIGNAL. IF TWO BLOCKING OCCURS, THE WINCH CONTROL VALVE RELIEF WILL ALTERNATELY OPEN AND CLOSE. THIS WILL CAUSE THE LOAD TO ALTERNATELY RAISE AND LOWER OR CHATTER. THE COUNTERBALANCE VALVE ON THE WINCH MOTOR MODERATES THE CHATTER. DELAY IN OPERATIONS.	NO EFFECT.	3
	ANTI-TWO BLOCK SYSTEM WARNING DEVICES (INSIDE BOOM LENGTH/BOOM ANGLE INDICATOR	ALERTS THE OPERATOR THAT TWO BLOCK SITUATION IS IMMINENT.	A. FAILS CLOSED B. FAULTY COMPONENTS	WARNING DEVICES WILL BE SIGNALING CONTINUOUSLY. DELAY IN OPERATIONS.	NO EFFECT.	3

FAILURE MODE AND EFFECTS ANALYSIS (FMEA) WORKSHEET

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System <u>LINK-BELT 40-TON MOBILE CRANE</u>		Facility or Station Set <u>MULTIPLE SS/99</u>			
Subsystem <u>ELECTRICAL</u>		Page <u>19</u> of <u>19</u> Date <u>JUNE 1989</u>			
Drawing No. <u>SKETCH SM6-47-36.0</u> Sheet No. <u>        </u>		Prepared By <u>R. B. BRINSMADE, LSOC 51-22</u>			
PMN <u>H72-1394</u>		Program <u>SPACE SHUTTLE</u>			
FIND NO.	PART NAME	PART FUNCTION	FAILURE MODE	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
			A. FAILURE MODE B. CAUSE C. FMN D. DETECTION METHOD E. CORRECTING ACTION F. TIME TO EFFECT G. TIMEFRAME	FAILURE EFFECT ON VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT

ANTI-TWO  
BLOCK SYSTEM  
WARNING DE-  
VICES (INSIDE  
BOOM LENGTH/  
BOOM ANGLE  
INDICATOR  
(CONT'D)

A. FAILS OPEN  
B. FAULTY COMPONENTS  
C. NA  
D. AUDIBLE/VISUAL  
E. THE OPERATOR WILL STOP HOISTING BY RELEASING THE CONTROL VALVE LEVER  
F. SECONDS  
G. IMMEDIATE

WARNING DEVICES WILL NOT SIGNAL. IF TWO BLOCKING OCCURS, THE WINCH CONTROL VALVE RELIEF WILL ALTERNATELY OPEN AND CLOSE. THIS WILL CAUSE THE LOAD TO ALTERNATELY RAISE AND LOWER OR CHATTER. THE COUNTERBALANCE VALVE ON THE WINCH MOTOR MODERATES THE CHATTER. DELAY IN OPERATIONS.

NO EFFECT.

3

## 2.7 FLEXHOSE FMEA WORKSHEETS

The flexible hoses which serve this system have been identified and are analyzed on the following Flexhose FMEA worksheets (form 29-463).

FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - STEERING Program SPACE SHUTTLE Page 1 of 2 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                      Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
LINK-BELT 58J0405 (PM1-9-59.0) (REF. 1-PRESSURE LINE)		SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
LINK-BELT 37J0306 (PM1-9-59.0) (REF. 18-PRESSURE LINE)		SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
LINK-BELT 46J1313 (PM7-22-20.1) (REF. 5-PRESSURE LINE)		SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
LINK-BELT 47A0812 (PM7-22-20.1) (3 EACH) (REF. 6- PRESSURE LINE)		SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
LINK-BELT 47A0811 (PM7-22-20.1) (REF. 7-PRESSURE LINE)		SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - STEERING Program SPACE SHUTTLE Page 2 of 2 Date JUNE 1989  
 Baseline 330.00 Drawing No. \_\_\_\_\_ Sheet No. \_\_\_\_\_ Prepared By R. BRINSMAN, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 58J0176 (PM7-22-20.1) (REF. 17-PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 57J0173 (PM7-22-20.1) (REF. 22-PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 822013005 (PM7-22-20.1) (REF. 27-PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - WINCH Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                      Prepared By R. BRINSMAN, L50C 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 45J1491 (PM5-4-82.0) (REF. 2-MOTOR TO BRAKE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 63J0058 (PM7-6-162.4) (REF. 17-MOTOR TO VALVE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 63J0055 (PM7-6-162.4) (REF. 18-MOTOR TO VALVE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 822026002 (PM7-6-162.4) (REF. 25-VALVE TO ROTATING JOINT)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - OIL COOLER Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                       
 Program SPACE SHUTTLE Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
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LINK-BELT 822026001 (PM1-79-66.0) (6 EACH) (REF. 3, 6, 11, 13, 15, & 17 - ROTATING JOINT TO OIL COOLER TO RESERVOIR)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	NA	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - SUCTION PRESSURE X RETURN Program SPACE SHUTTLE Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.          Sheet No.          Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 822006002 (PM1-79-65.1)	SYNTHETIC RUBBER, STEEL WIRE	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	(REF. 1 - PUMP SUCTION LINE FROM MANIFOLD)	BRAID REIN- FORCED.						
	LINK-BELT 822006003 (PM1-79-65.1)	SYNTHETIC RUBBER, STEEL WIRE	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	(REF. 2 - PUMP SUCTION LINE FROM MANIFOLD)	BRAID REIN- FORCED.						
	LINK-BELT 822006004 (PM1-79-65.1)	SYNTHETIC RUBBER, STEEL WIRE	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	(REF. 3 - PUMP SUCTION LINE FROM MANIFOLD)	BRAID REIN- FORCED.						
	LINK-BELT 822030004 (PM1-79-65.1)	SYNTHETIC RUBBER, STEEL WIRE	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	(REF. 6 - PUMP SUCTION LINE FROM MANIFOLD)	BRAID REIN- FORCED.						

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FLEXHOSE FMEA WORKSHEET

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System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - OUTRIGGER Program SPACE SHUTTLE Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                      Prepared By R. BRINSMAN, L50C 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 822013012 (PM1-38-119.2) (REF. 30 - RETURN LINE FROM VALVE TO TANK MANIFOLD)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 46A1338 (PM1-38-119.2) (REF. 34 - FEED LINE FROM ROTATING JOINT TO FRONT/BACK DISTRI- BUTION LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 36J0918 (PM1-38-119.2) (8 EACH) (REF. 48, 52, * 56 - FRAME TO BEAM, FRONT AND BACK)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 53A0504 (PM1-45-70.0) (8 EACH) (REF. 2 - LOCK VALVE TO JACK CYLINDER)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 58J0200 (PM1-46-70.0) (4 EACH) (REF. 14 - LOCK VALVE TO JACK CYLINDER)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - BOOM Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                       
 Program SPACE SHUTTLE Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 41J0158 (PM17-2-55.0) (3 EACH) (REF. 5 - FRAME TO BOOM)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 63J0104 (PM17-3-66.2) (REF. 17 - CONNECTION BETWEEN LOCK VALVES)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 63J0103 (PM17-3-66.2) (2 EACH) (REF. 18 - CONNECTION BETWEEN LOCK VALVES)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FILEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Program SPACE SHUTTLE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - MAIN LINES Drawing No.                      Sheet No.                      Page 1 of 2 Date JUNE 1989  
 Baseline 330.00 Prepared By R. BRINSMAN, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 63J0064 (PM7-6-144.5) (REF. 1 - BOOM HOIST CYLINDER TO VALVE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 46J1330 (PM7-6-144.5) (REF. 5 - SWING MOTOR TO SWING TELESCOPE VALVE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 822013005 (PM7-6-144.5) (REF. 9 - OUTRIGGER RETURN LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 36J0212 (PM7-6-144.5) (REF. 10 - SWING MOTOR TO SWING TELESCOPE VALVE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 63J0065 (PM7-6-144.5) (REF. 26 - BOOM HOIST CYLINDER TO VALVE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - MAIN LINES Program SPACE SHUTTLE Page 2 of 2 Date JUNE 1989  
 Baseline 330.00 Drawing No. \_\_\_\_\_ Sheet No. \_\_\_\_\_ Prepared By R. BRINSMAN, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 822026002 (PM7-6-144.5)(2 EACH) (REF. 38 - RETURN LINE, VALVE TO RESERVOIR)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
	LINK-BELT 46A1728 (PM7-6-144.5) (REF. 39 - SWING TELE- SCOPE VALVE TO ROTATING JOINT)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
	LINK-BELT 57J0168 (PM7-6-144.5) (REF. 64 - SWING/ TELESCOPE VALVE TO ROTATING JOINT)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
	LINK-BELT 57J0167 (PM7-6-144.5) (REF. 65 - SWING/ TELESCOPE VALVE TO ROTATING JOINT)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
	LINK-BELT 57J0173 (PM7-6-144.5) (REF. 69 - SWING/ TELESCOPE VALVE TO ROTATING JOINT)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - RESERVOIR Program SPACE SHUTTLE Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                      Prepared By R. BRINSMADE, L50C 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 822026003 (PM1-39-47.1)(3 EACH) (REF. 19 - RETURN LINE FROM ROTATING JOINT	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 822013007 (PM1-39-47.1) (REF. 20 - RETURN LINE FROM VALVE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 822006006 (PM1-39-47.1) (REF. 23 - SUCTION LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - ROTATING JOINT Program SPACE SHUTTLE Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                      Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 822026002 (PM1-48-80.1) (REF. 7 - PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 57J0180 (PM1-48-80.1) (REF. 17 - PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 57J0182 (PM1-48-80.1) (REF. 18 - PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 57J0181 (PM1-48-80.1) (REF. 19 - PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - LOCKOUT VALVE Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                      Prepared By R. BRINSMAN, L50C 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 76J0040 (PM1-78-29.0) (2 EACH) (REF. 5 - PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 45J0460 (PM1-78-29.0) (2 EACH) (REF. 7 - PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 822013007 (PM1-78-29.0) (REF. 9 - PRESSURE LINE)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System		LINK-BELT 40-TON MOBILE CRANE		Facility/Station Set		MULTIPLE			
Subsystem		ENGINE, CONVERTOR AND PUMPS		Page		1 of 3 Date			
Baseline		330.00		Drawing No.		Sheet No.			
Program		SPACE SHUTTLE		Prepared By		R. BRINSMADE, LSOC 51-22			
FIND NO.	KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
		LINK-BELT 36A2688 (PM1-75-137.0) (REF. 26 - VALVE TO CONVERTOR)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
		LINK-BELT 20H0160 (PM1-75-137.0) (REF. 47 - AIR CLEANER JOINT)	SYNTHETIC RUBBER, FIBER REINFORCED.	AIR (ATMOSPHERIC)	TBD	NA	NA	AIR LEAKS. OPERATIONS.	NC
		LINK-BELT 37A1130 (PM1-75-137.0) (REF. 51 - SUPPLY LINE TO THROTTLE LOCK VALVE)	SYNTHETIC RUBBER, FIBER REINFORCED.	AIR (COMPRESSED)	TBD	NA	NA	AIR LEAKS. OPERATIONS.	NC
		LINK-BELT 46A1838 (PM1-75-137.0) (REF. 53 - SUPPLY LINE FROM RESERVOIR)	SYNTHETIC RUBBER, FIBER REINFORCED.	AIR (COMPRESSED)	TBD	NA	NA	AIR LEAKS. OPERATIONS.	NC
		LINK-BELT 53A0853 (PM1-75-137.0) (REF. 58 - PRESSURE LINE FROM STEERING PUMP)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem ENGINE, CONVERTOR AND PUMPS Page 2 of 3 Date JUNE 1989  
 Baseline 330.00 Drawing No. \_\_\_\_\_ Sheet No. \_\_\_\_\_ Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 46A1533 (PM1-75-137.0) (REF. 61 - PRESSURE LINE FROM MAIN PUMP)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 46A1117 (PM1-75-137.0) (REF. 63 - PRESSURE LINE FROM MAIN PUMP)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 46A1116 (PM1-75-137.0) (REF. 64 - PRESSURE LINE FROM MAIN PUMP)	SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	3000/4500/ 12000	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 46A1416 (PM1-75-137.0) (REF. 75 - TRANSMIS- SION PRESSURE LINE)	SYNTHETIC RUBBER, FIBER REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
	LINK-BELT 46A1362 (PM1-75-137.0) (2 EACH) (REF. 78 AND 79 - TRANSMISSION PRESSURE LINES)	SYNTHETIC RUBBER, FIBER REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem ENGINE, CONVERTOR AND PUMPS Program SPACE SHUTTLE Page 3 of 3 Date JUNE 1989  
 Baseline 330.00 Drawing No. \_\_\_\_\_ Sheet No. \_\_\_\_\_ Prepared By R. BRINSMADE, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
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LINK-BELT 46A1357 (PM1-75-137.0) (REF. 82 - TRANSMIS- SION PRESSURE LINES)	SYNTHETIC RUBBER, FIBER REIN- FORCED.	HYDRAULIC	TBD	NA	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - AXLES Program SPACE SHUTTLE Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                      Prepared By R. BRINSMAN, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
LINK-BELT 36J1570 (PM1-29-38.1) (4 EACH) (REF. 8 - STEERING CYLINDER HOSES)		SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
LINK-BELT 37J0309 (PM1-2-132.0) (4 EACH) (REF. 4 - STEERING CYLINDER HOSES)		SYNTHETIC RUBBER, STEEL WIRE BRAID REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC
LINK-BELT 46A1873 (PM1-2-132.0) (PM1-29-38.1) (4 EACH) (REF. 20 - BRAKE HOSES)		SYNTHETIC RUBBER, FIBER REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. DELAY IN OPERATIONS.	NC

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FLEXHOSE FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE  
 Subsystem HYDRAULIC - TRANSMISSION Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No.                      Sheet No.                      Prepared By R. BRINSMAD, L50C 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	MATERIAL	FLUID MEDIA	DIAMETER (INCHES)	MAX OPER/PROOF/ BURST PRESSURE (PSIG)	BEND RADIUS	FAILURE EFFECT	CRIT CAT
	LINK-BELT 46A1361 (PM1-19-96.1) (REF. 4 - PRESSURE LINE)	SYNTHETIC RUBBER, FIBER REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
	LINK-BELT 46A1359 (PM1-19-96.1) (REF. 5 - PRESSURE LINE)	SYNTHETIC RUBBER, FIBER REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
	LINK-BELT 53A0474 (PM1-19-96.1) (REF. 9 - PRESSURE LINE)	SYNTHETIC RUBBER, FIBER REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. OPERATIONS.	NC
	LINK-BELT 46A1360 (PM1-19-109.0) (REF. 10 - PRESSURE LINE)	SYNTHETIC RUBBER, FIBER REIN- FORCED.	HYDRAULIC	TBD	NA	NA	HYDRAULIC LEAKS. OPERATIONS.	NC

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## 2.8 ORIFICE FMEA WORKSHEETS

There were no critical orifices identified in this analysis. The hydraulic and compressed air systems, which are analyzed in their respective FMEA worksheets, contain orifices which are an integral part of those systems components.

## 2.9 FILTER FMEA WORKSHEETS

The filters which serve this system have been identified and are analyzed on the following Filter FMEA worksheet (form 29-462).

FILTER FMEA WORKSHEET

System LINK-BELT 40-TON MOBILE CRANE Facility/Station Set MULTIPLE/99  
 Subsystem HYDRAULIC Program SPACE SHUTTLE Page 1 of 1 Date JUNE 1989  
 Baseline 330.00 Drawing No. LINK-BELT Sheet No. PM1-39-44.0 Prepared By R. BRINSWADE, LSOC 51-22

FIND NO. KSC PART NO.	MANUFACTURER NAME & PART NO.	PART FUNCTION	FILTER RATING	DESIGN/BURST PRESSURE (PSIG)	COLLAPSE PRESSURE (PSID)	FAILURE MODE	FAILURE EFFECT ON SYSTEM PERFORMANCE/VEHICLE SYSTEMS AND/OR PERSONNEL SAFETY	CRIT CAT
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NA	LINK-BELT 76J0551	FILTERS FLUID AT THE RESERVOIR RETURN PORT.	2 MICRON	NA	NA	CLOGS	HYDRAULIC FLOW INTERRUPTED. A SPRING BYPASS VALVE ALLOWS FLOW TO CONTINUE CIRCULATING AND KEEPS SYSTEM OPERATIONAL. DELAY FOR REPAIR.	NC
							PASSES CONTAMINANTS	NC

NA	LINK-BELT 3J5435	FILTERS AIR AS IT TRAVELS FROM THE ATMOSPHERE THROUGH THE VACUUM/PRESSURE RELIEF VALVE ASSEMBLY TO THE RESERVOIR AND VICE VERSA.	NA	NA	NA	CLOGS	AIR FLOW INTERRUPTED TO AND FROM RESERVOIR. IF EXCESSIVE AIR PRES-SURE DEVELOPS, AIR WILL PASS INTO OIL AND CAUSE PUMP CAVITATION AND POSSIBLE DAMAGE. IF VACUUM DEVELOPS, RESERVOIR MAY POSSIBLY CAVE-IN AND CAUSE PUMP CAVITATION AND POSSIBLE DAMAGE. DELAY FOR REPAIR.	NC
							PASSES CONTAMINANTS	NC

							PASSES CONTAMINANTS	NC
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### 3.0 CRITICAL ITEMS LIST (CIL)

There were two Critical Items identified in this system which are summarized on the following Critical Hardware List and associated Critical Item Analysis Sheets.

### 3.1 CRITICAL HARDWARE LIST (CHL)

The Critical Items identified in this system are summarized on the following Critical Hardware List.

SAA09FT01-006  
 B/L: 330.00  
 SYS: LINK-BELT  
 40-TON  
 MOBILE CRANE  
 HSP-8040

Critical Hardware List

Project Element: Cranes, Mobile

Subsystem: Link-Belt 40-Ton Mobile Crane HSP-8040

Page 1 of 1

LRU PART NUMBER/ REFERENCE DESIGNATOR	LRU PART NAME	QTY (per subsystem)	LRU CRITICALITY
FMEA P/N	FMEA PART NAME/FM NO.	(QTY per LRU)	FM CRIT
LRU P/N MODEL 10/KIT 420	REDUCTION UNIT ASS'Y., WINCH	1	1
MODEL 10/KIT 420	REDUCTION UNIT ASS'Y. FM NO. 09FT01-006.001	1	1
LRU P/N 37805	BRAKE, WINCH	1	1
37805	BRAKE FM NO. 09FT01-006.002	1	1
LRU P/N 46F0085	SWING SPEED REDUCER ASSEMBLY	2	2
46F0085	SWING SPEED REDUCER ASSEMBLY FM NO. 09FT01-006.003	2	2

### 3.2 CRITICAL ITEMS ANALYSIS SHEETS

The following Critical Items Analysis Sheets identify the rationale for accepting the risk of retaining the Critical Items.

SAA09FT01-006  
B/L: 330.00  
SYS: LINK-BELT  
40-TON  
MOBILE CRANE  
HSP-8040

Critical Item: Reduction Unit Ass'y. (1 Item)

Find Number: Model 10/Kit 420

Criticality Category: 1

SAA No: 09FT01-006

System/Area: Link-Belt 40-Ton Mobile  
Crane/Multiple Station  
Sets

NASA  
Part No: N/A

PMN/ H72-1394/  
Name: Link-Belt 40-Ton Mobile Crane

Mfg/ Auburn Gear  
Part No: Model 10/Kit 420,  
(FN: 46D0102)

Drawing/ Link-Belt  
Sheet No: PM 5-7-74.0

Function: Transfers torque from the winch drive hydraulic motor to the winch wire rope drum.

Critical Failure Mode: Gears Disengage. FM No. 09FT01-006.001.

Failure Cause: Structural failure of the gear assembly.

Failure Effect: Torque for holding load will be lost. Load suspended from hook may drop. Possible loss of life, vehicle or loss (damage) to a vehicle system could result if a load containing hazardous materials (e.g., the hydrazine cart at the launch pad) were dropped.

#### Acceptance Rationale

##### Design:

- o The Reduction Unit Assembly is an off-the-shelf item manufactured by Auburn Gear. Its design complies with AGMA and SAE standards.
- o The gears are splined to shafts or integrally machined and are retained in place by shoulders within the confines of the gearcase.
- o The manufacturer has factory tested a sample Reduction Unit Assembly for static ultimate strength and found the output torque to exceed 450,000 inch-pounds. The unit is rated at 90,000 inch-pounds for continuous operation. This results in a safety margin of 5 to 1.
- o Vendor load charts are provided with the mobile crane specifying load, boom angle, and boom extension to prevent overloading the Reduction Unit Assembly, which would lead to damage or failure.

SAA09FT01-006  
B/L: 330.00  
SYS: LINK-BELT  
40-TON  
MOBILE CRANE  
HSP-8040

Reduction Unit Ass'y. Model 10/Kit 420 (Continued)

Test:

- o In accordance with NASA safety standard for lifting devices and equipment, NSS/GO-1740.9, mobile cranes shall be load tested and operationally tested within 12 months prior to performing a critical lift. The mobile crane will be load tested with a load equal to the rated load at the minimum radius in accordance with the manufacturer's load chart. Being a part of the hoisting system, the Reduction Unit Assembly is included in the load test.
- o OMRSD File VI will require verification of annual load test prior to each critical use.
- o PMI No. HDO will require annual oil sample testing by spectographic or chemical analysis.

Inspection:

- o PMI No. HDO requires quarterly inspections to:
  - examine unit for weld cracks and structural damage
  - inspect and maintain gear oil level in the reduction unit assembly

Failure History:

- o No failure history was found at the manufacturer, in the GIDEP data base, or the PRACA data base.

Operational Use:

- o Correcting Action:

There is no action which can be taken to mitigate the failure effect.
- o Timeframe:

Since no correcting action is available, timeframe does not apply.

SAA09FT01-006  
B/L: 330.00  
SYS: LINK-BELT  
40-TON  
MOBILE CRANE  
HSP-8040

Critical Item: Winch Brake Ass'y. (1 Item)

Find Number: 37805

Criticality Category: 1

SAA No: 09FT01-006

System/Area: Link-Belt 40-Ton Mobile  
Crane/Multiple Station  
Sets

NASA  
Part No: N/A

PMN/ H72-1394/  
Name: Link-Belt 40-Ton Mobile Crane

Mfg/ AUSCO  
Part No: 37805  
(FN: 53D0098)

Drawing/ Link-Belt  
Sheet No: PM 5-12-124.0

Function: Prevents rotation of winch drum when winch drive motor is not operating and when load is suspended.

Critical Failure Mode: Brake slips or fails to engage. FM No. 09FT01-006.002.

Failure Cause: Structural failure of the brake mechanism.

Failure Effect: Torque for holding load will be lost. Load suspended from hook may drop. Possible loss of life, vehicle or loss (damage) to a vehicle system could result if a load containing hazardous materials (e.g., the hydrazine cart at the launch pad) were dropped.

#### Acceptance Rationale

##### Design:

- o The Winch Brake Assembly is an off-the-shelf item manufactured by Auto Specialties Manufacturing Co. (AUSCO).
- o The rotating discs are splined to the output shaft, the stationary discs are grooved to fit into the piston and are retained in place by shoulders within the confines of the brake housing.

SAA09FT01-006  
B/L: 330.00  
SYS: LINK-BELT  
40-TON  
MOBILE CRANE  
HSP-8040

Winch Brake Ass'y. 37805 (Continued)

- o Vendor load charts are provided with the mobile crane specifying load, boom angle, and boom extension to prevent overloading the Winch Brake Assembly which would lead to damage or failure.

Test:

- o In accordance with NASA safety standard for lifting devices and equipment, NSS/G0-1740.9, mobile cranes shall be load tested and operationally tested within 12 months prior to performing a critical lift. The mobile crane will be load tested with a load equal to the rated load at the minimum radius in accordance with the manufacturer's load chart. Being a part of the hoisting system, the Winch Brake Assembly is included in the load test.
- o OMRSD File VI will require verification of annual load test prior to each critical use.

Inspection:

- o PMI No. HDO requires quarterly inspections to:
  - examine unit for weld cracks and structural damage

Failure History:

- o No failure history was found at the manufacturer, in the GIDEP data base, or the PRACA data base.

Operational Use:

- o Correcting Action:

There is no action which can be taken to mitigate the failure effect.
- o Timeframe:

Since no correcting action is available, timeframe does not apply.

SAA09FT01-006  
B/L: 330.00  
SYS: LINK-BELT  
40-TON  
MOBILE CRANE  
HSP-8040

Critical Item: Swing Speed Reducer Assembly (1 Item)

Find Number: 46F0085

Criticality Category: 2

SAA No: 09FT01-006

System/Area: Link-Belt 40-Ton Mobile  
Crane/Multiple Station  
Sets

NASA  
Part No: N/A

PMN/ H72-1394/  
Name: Link-Belt 40-Ton Mobile Crane

Mfg/ Gear Prod. Inc.  
Part No: (FN: 46F0085)

Drawing/ Link-Belt  
Sheet No: PM 4-10-17.0

Function: Transfers torque from the swing drive hydraulic motor to the turntable assembly.

Critical Failure Mode: Gears disengage. FM No. 09FT01-006.003.

Failure Cause: Structural failure of the gear assembly.

Failure Effect: Torque for controlling the horizontal rotation and holding upper structure in position will be lost. Load may impact flight hardware and/or GSE resulting in damage to flight hardware.

#### Acceptance Rationale

##### Design:

- o The Swing Speed Reducer is an off-the-shelf item from Gear Products Inc., Tulsa OK. Its design is in accordance with AGMA and CMAA standards.
- o The Swing Brake is included in the assembly and is actuated by manual force applied through the Swing Brake foot pedal.
- o The gears are splined to the shafts or integrally machined and are retained in place by shoulders within the confines of the gearcase.

SAA09FT01-006  
B/L: 330.00  
SYS: LINK-BELT  
40-TON  
MOBILE CRANE  
HSP-8040

Swing Speed Reducer Assembly 46F0085 (Continued)

Test:

- o In accordance with NASA safety standard for lifting devices and equipment, NSS/GO-1740.9, mobile cranes shall be load tested and operationally tested within 12 months prior to performing a critical lift. The mobile crane will be load tested with a load equal to the rated load at the minimum radius in accordance with the manufacturer's load chart. The swing function will be operationally verified during this test.
- o OMRSD File VI will require verification of annual load test prior to each critical use.

Inspection:

- o PMI No. HD0 requires quarterly inspection to:
  - examine unit for weld cracks and structural damage
  - inspect and maintain gear oil in the gearcase.

Failure History:

- o No failure history was found at the manufacturer, in the GIDEP data base, or the PRACA data base.

Operational Use:

- o Correcting Action:

There is no action which can be taken to mitigate the failure effect.
- o Timeframe:

Since no correcting action is available, timeframe does not apply.

#### 4.0 HAZARD ANALYSIS

There were no hazards identified in this equipment (see KSC form 21-428).

System Safety Engineering has identified one safety item of concern. NSS/GO 1740.9, 3.2.5, f, within the NASA safety standard for lifting devices and equipment state that mobile cranes shall have at least one upper limit switch to prevent two blocking. The referenced Link Belt mobile crane does not comply with this requirement. Section 1.4 titled Applicability and Exclusions within 1740.9, dated July 1988 also states, "The design requirements contained herein are applicable to new hardware purchased after six months from the issue date of this document". The Link Belt mobile crane was purchased approximately a year and a half ago.

A separate and comprehensive NASA study for lifting devices is underway according to NASA Safety and NSS/GO 1740.9, 1.4 which states, "existing equipment will be reviewed for compliance with design aspects of this standard within 12 months of its issue". At the end of NASA's scheduled one year study, any lifting device found in violation will either be given a permanent waiver or action will be implemented to eliminate any standard violations.

HAZARD IDENTIFICATION DATA

SAA09FT01-006

SYSTEM/SUBSYSTEM (Title) Link Belt 40-Ton Mobile Crane at KSC	WO	PMN H72-1394	PCN
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The following hazard identification criteria were considered during the hazard analysis:

DESIGN SAFETY CHECKLIST SECTION NUMBER AND TITLE:

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- 

- HAZARD ANALYSIS ELEMENTS (GP-1045, APPENDIX B)
- FAILURE MODE AND EFFECT ANALYSIS (FMEA)
- FUNCTIONAL AND PHYSICAL INTERFACES
- OCCUPATIONAL SAFETY AND HEALTH STANDARDS (OSHA)
- SW-E-0002, SPACE SHUTTLE PROGRAM GSE GENERAL DESIGN REQUIREMENTS

The Hazard Analysis was based on the following system documentation (list documents here):  
B/L: 330.00

<u>Document/Drawing Number</u>	<u>Title</u>
GP-1045	Hazard Analysis Instructions
KSC-STD-0002B	Design Requirements For Lifting and Hoisting Equipment
NSS/GO-1740.9	NASA Safety Standard For Lifting Devices and Equipment
29CFR 1910	OSHA Standards
NSTS 22254	Methodology For Conducting NSTS Hazard Analysis

No hazards identified .

 8/29/89  
System Safety Engineer

DESIGNER: Paul R. Schuch 8-29-89 Supervisor, System Safety Engineering	APPROVED (NASA):
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## 5.0 CONTROL LOGIC ANALYSIS

### 5.1 SOFTWARE APPLICATION SET REVIEW

There is no prerequisite or reactive control logic associated with this system; therefore, no Software Application Set Review is required.

### 5.2 GROUND LAUNCH SEQUENCER REVIEW

There are no Ground Launch Sequencer sequences required for this system; therefore, no Ground Launch Sequencer Review is required.

### 5.3 LAUNCH COMMIT CRITERIA REVIEW

There are no Launch Commit Criteria requirements for this system; therefore, no Launch Commit Criteria Review is required.

### 5.4 LPS/CCMS CONTROL FUNCTION ANALYSIS

There are no LPS/CCMS Function Designators (FDs) associated with this system.

## 6.0 END-TO-END ANALYSIS

### 6.1 END-TO-END SYSTEM SUMMARY

The Link Belt 40-Ton Mobile Crane HSP-8040 is a commercially designed and constructed piece of equipment. The mobile crane complies with all OSHA and ANSI requirements. This hoist is intended to interface with standard lifting shackles and slings.



End-To-End Block Diagram

## 6.2 AREAS OF CONCERN

The following Area of Concern was identified during this analysis:

- a. The mobile crane has an audio/visual anti-two block system that alerts the operator that a two block situation (hook block or ball contacting the sheaves of the boom head machinery) is imminent. The system is activated when the hook ball or block contacts a suspended weight. The operator stops hoisting to prevent the two block situation. This system is not the same as the one upper limit switch to prevent two blocking as required by paragraph 3.2.6.F of NSS/GO-1740

## 7.0 SNEAK CIRCUIT ANALYSIS

There was no Sneak Circuit Analysis performed on this system.

## 8.0 EMERGENCY SAFING ANALYSIS

There are no emergency safing circuits associated with this system.

## 9.0 CRITICALITY CATEGORY 1R STAR (1R\*) ITEMS

There were no category 1R\* items identified during the analysis of the critical output functions identified in section 2.4 for this equipment.